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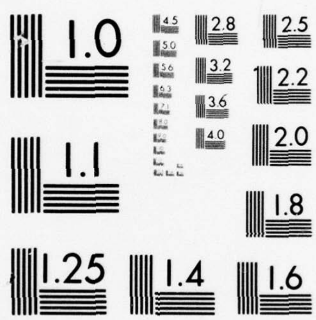

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CASE STUDIES IN MARITIME INNOVATION NAS

Case Studies in Maritime Innovation

The National Research Council

Maritime Transportation Research Board

Commission on Sociotechnical Systems

CASE STUDIES IN MARITIME INNOVATION

prepared for the
Maritime Transportation Research Board
Commission on Sociotechnical Systems
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FOREWORD

These *Case Studies in Maritime Innovation* were developed for the Maritime Transportation Research Board's Committee on Innovation and Technology Transfer in the Maritime Industry. They are published here in a volume separate from the Committee's final report because they are believed to be of value as an independent reference source. Each study traces the development of the selected innovation, as well as identifying barriers and incentives that influenced that development.

All facts and opinions expressed in the studies are those of the authors and do not reflect the opinions or deliberations of the Committee, the Board, or the National Academy of Sciences.

Edward M. MacCutcheon
Chairman
Committee on Innovation and Technology Transfer in the Maritime Industry

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Chairman
Maritime Transportation Research Board

Washington, D.C.
April 1978

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EVOLUTION OF THE CONCEPT AND ADOPTION OF THE MARINE AND INTERMODAL CONTAINER

Francis G. Ebel

SCOPE

To elaborate on the title of this case study, this innovation is taken to encompass what amounts to a complete transportation system for marine cargo from its point of origin to the point of final destination utilizing a large unit load and without rehandling individual pieces of cargo.

The elements of the system include the container itself, the container ship, marine terminals, land transport vehicles, transfer equipment, integration with other forms of transport, and management control systems.

THE ENVIRONMENT

The Existing System

Prior to the widespread adoption of containers, the existing system of overseas shipment consisted in the shipper or freight forwarder loading the commodities into truck or rail car at his plant, transporting it to the marine terminal in the seaport from where the water leg would begin, discharging from the land vehicle, storage in the pier shed awaiting ship arrival, loading into the ship, and then repeating the process in reverse order at the other end. In some ports, an additional step was involved--transporting the shipment from the railhead in the port to the ship terminal by lighter. While pallets were coming increasingly into use to reduce the amount of hand labor, more often than not packages were handled and stowed individually. Planning the stowage in the ship required great skill. In most cases a number of different shipments had to be stowed in the same hold, creating the need for extensive dunnaging, flooring off, and bulkheading. Since different stowage levels in the same hold are served by a common hatch, overstow was a serious problem.

The Terminal

Most of the marine terminals in the United States and around the world were antiquated and inadequate. They were poorly designed for traffic flow, and transit sheds were invariably cluttered and poorly lighted. Port congestion was a serious problem in many areas of the world. Some of this was due to the steamship lines' practice of concentrating sailings on a particular day of the week. For example, 50 percent of all sailings from the port of New York occurred on Friday.[3] In some foreign ports, ships might wait days for a berth. In many cases the terminals were publicly owned, or owned by a separate entity, and therefore not under control of the steamship line or the stevedore contractor who used them.

The Cargo

The nature of the cargo itself was a problem. A study of longshore labor published by the Department of Labor in 1932 defined general cargo as follows: "A large number of heterogeneous commodities in an endless variety of containers". The term mechanization carries with it an implication of some sort of standard article or repetitive operation. As long as the cargo clung to the above definition little could be done to apply mechanization.

The Ship

The miscellaneous nature of the cargo likewise dictated the configuration of the ship, which had traditionally been designed to carry "anything" "anywhere." The philosophy and organization of ship design establishments were not cargo-handling oriented. The usual ship design process consisted of taking the owner's basic requirements in terms of carrying capacity and speed, and deriving the dimensions and form of the hull to attain the specified characteristics with a minimum of power. Whatever came out of this was the thing cargo was stowed in. Ship form and propulsion machinery held top priority. No one person or group in the design organization was responsible for the cargo-handling function of the ship. Even the overall arrangement of the ship was discriminatory. The propulsion machinery, navigating bridge, and crew accommodations were invariably located in the full, comfortable midbody of the ship. The space left over was good enough for the cargo. Even the structural designer tended to be unfriendly, frequently decorating the cargo spaces with pillars, frame brackets, and other odd bric-a-brac that hindered movement and stowage. Other cargo inhibitors were sheer and camber in

decks, small hatch openings, crude, inadequate hatch closures, and lack of decent lighting.

The cargo-handling gear was accorded a minimum of engineering, with the result that it was primitive and unsafe. Incredibly, there were no regulatory requirements for testing the gear other than those established administratively by the Maritime Commission on ships built under the Merchant Marine Act of 1936.

Stevedoring

It has been common practice in the shipping industry to subcontract the loading and discharge of cargo to a stevedoring contractor. In this kind of arrangement the party doing the actual work has little or no control over the facilities he uses. He must take the ship, the cargo gear, and the terminal as he finds them. In some respects, his interests are in conflict with the shipowner.

Longshore Labor and Labor Relations

Historically, labor relations in the longshore industry have been stormy worldwide. Longshore labor unions have traditionally opposed the introduction of mechanization or labor-saving devices that would result in increased productivity, with consequent threat of loss of jobs. Waterfront history is replete with horror stories of local union rules requiring unnecessary re-handlings and other obstructive practices. On the management side, enlightened labor relations policies and effective industry-wide bargaining were yet to be discovered. Strikes were frequent and costly.

Diversity of Control, Lack of Coordination

The several elements that make up the cargo-handling operation--the ship, the stevedore, and the terminal--are controlled by separate entities, each with different interests. This has acted as an inhibitor to improving this function. Each of the parties had a limited knowledge of and appreciation for the other's problems. There was little coordination between the ship designer, the ship operator, and the stevedore.

Steamship Management

The management of steamship companies historically has been extremely conservative and heavily tradition-bound.

Sea experience appears to have been the most important qualification for managerial positions. Technical training and imagination were secondary. Little attention was given to research or long-range planning. This deficiency was an important factor in the containerization era.

The Fleet

A large proportion of the world's merchant fleet had been destroyed during World War II. The United States, as a result of a huge wartime shipbuilding effort, had on hand a large fleet of ships of prewar design. The Ship Sales Act of 1946 made these ships available to U.S. steamship operators, both subsidized and unsubsidized. Since many of these ships were virtually brand new and selling on attractive terms, the Act was a boon to the unsubsidized operator. The subsidized operator, however, was committed to replacing his ships with new construction.

The Mariner Program

Due to this glut of war-built ships, there was virtually no new cargo ship construction in the United States in the postwar period until the Maritime Administration undertook the Mariner Program in 1950, utilizing Title 7 of the Merchant Marine Act. This program was undertaken at the urging of the Department of Defense, which had identified the need for a fleet of high-speed cargo ships "in existence" for use as naval auxiliaries in time of war. Thirty-five of these ships were eventually built, and some saw service in the Korean War. While these ships did set a new size and speed level for merchant ships, and contained many useful refinements, the design was basically no different from prewar designs. The Mariner was still a typical break-bulk cargo ship. Although at first roundly criticized by commercial operators as too large and overpowered, thirty of them were acquired by the subsidized lines at depreciated prices and proved to be successful. For the next decade, the Mariner became the standard of comparison for cargo ships worldwide.

Inflation in Labor Costs

The inevitable postwar inflation in the decade of the 1950s brought a severe escalation in labor costs without compensating increases in productivity. This was particularly marked in the case of longshore labor. In a well-documented study[5] published in 1961, MacMillan and Westfall showed that for the period 1947 to 1959, longshore labor costs had increased by 118 percent while productivity

had actually decreased. A prediction, made by the Department of Labor in 1932, that productivity in this industry would likely decline proved to be accurate. In other industries, increased productivity had reasonably kept up with higher wage rates. For the economy as a whole, labor productivity had increased at a rate of 3 percent a year during this period.

Summary of the Environment

Combining all of the factors and circumstances recited in this review of the shipping environment in the pre-container era, it became obvious that cargo handling was the dominant weakness in the system. In addition to the direct costs, two other factors further accentuated the problem. The wages of shipboard labor were escalating rapidly, and this cost, as well as other vessel costs, must be charged to the cargo-handling cost during the ship's stay in port. In addition, with the trend toward higher sea speed, the port stay assumed a larger proportion of total voyage time. At sea the ship was a very efficient vehicle. In port it was a disaster. Depending on the trade, port costs accounted for 60 percent or more of total systems cost.

The consequences of this struck the domestic trades first since they were in direct competition with land transport. Coastal and intercoastal operators went out of business. The situation for the operator in foreign trade was also bad, but not as serious, since his competitors were in the same condition. Still, if profit margins were to be improved by cutting costs, the point of attack was well identified. The time was right for some kind of breakthrough.

THE CONTAINER REVOLUTION

The history of containerization is a long one. This account is limited to the recent past.

Much credit must go to the U.S. Army Transportation Corps for development of the first extensive container transport operation. Motivation came primarily from their experiences in the supply of overseas armies during World War II and again in the Korean War. Protection of precious cargo during transit and temporary storage rather than economics was the principal attraction to the military. In the immediate postwar period, with the spectre of huge stacks of crushed, torn, and weathered military supplies piled high on open wharves around the world still fresh in their minds, they turned to the metal container as at least a partial solution to their problem. A careful analysis of

the full range of military cargo established that 40 percent of the total could be containerized to good advantage. The result of their study was the introduction of the Conex container, with standard dimensions suitable for transport by sea as well as by truck, rail, and army vehicles.

Cost is not the overriding factor in military operations. Very often, the value of timely receipt of critical spare parts and supplies by armies in the field can be counted in lives rather than dollars. The protection against mechanical damage and weather afforded by the metal container constituted a welcome improvement. Not to be lost sight of, too, was the larger unit load, with its potential for improved ship discharge rates, and quicker ship dispatch in severely congested ports such as had been experienced in Korea.

By 1965, when our major involvement in Viet Nam began, the Army and Air Force jointly owned a fleet of approximately 100,000 Conex containers. As the war escalated, this number was nearly doubled. Satisfaction with container shipment was so widespread in the military that full containership services using van-sized containers were introduced to Viet Nam in 1967.

Whether by coincidence or example, a sudden flurry of interest in containerization also appeared in the commercial shipping field in the early postwar period. Some visionary people were predicting the advent of container ships, and inventors were flooding the Patent Office with designs of containers and transfer systems. The Maritime Commission picked up the idea and built a C-3 vessel equipped with overhead deck cranes capable of handling unit loads of up to 30 tons. However, it was not to be; the commercial shipping industry was not yet ready to part with tradition and wrestle with the logistics problems and system innovations that large-scale adoption of containerization would entail.

Limited experimentation with commercial use of containers during this period was, like the use by the military, inspired by the protection afforded by the metal box. In this case, security of high-value cargoes against pilferage, the universal waterfront disease, was the motivation. Conditions for success of containerization during this early period were anything but propitious. Cargo ships were not designed to handle this type of cargo efficiently, with the result that the boxes were frequently damaged while being hoisted aboard or during the horizontal movement required to stow them in the wing spaces of 'tween decks. Return cargoes were frequently not available, so the boxes had to be returned empty. In spite of the problems and the vocal opposition of the ever-present detractors, the idea survived. The military continued to expand its Conex

container fleet, and commercially the container held its own in specialized applications.

Sea-Land

Oddly enough, it remained for a land transportation company to strike the spark that flamed into the integrated, intermodal transport concept of containerization. The experiment began when McLean Industries, parent company of McLean Trucking, acquired a steamship line, Pan Atlantic Steamship Company (later renamed Sea-Land Service). Malcom McLean, a clever and ingenious businessman, conceived the idea of carrying his trucks on a ship for the long haul from the Gulf ports to New York. The concept was developed in stages. The first step, in 1956, consisted in carrying the trailers on the spar deck of tankers operating between New York and Houston. The feasibility having been demonstrated, McLean proceeded with the design of a roll-on/roll-off trailership. After carrying the project to the contract plan stage, this concept was abandoned and the switch was made to the lift-on/lift-off principle.

In 1957-1958, six C-2 type ships were converted to full containerships equipped with shipboard-mounted cranes for load and discharge. The ships carried 226 thirty-five foot containers. Four of the six ships were put into service between East Coast and Gulf ports, and the other two between New York and Puerto Rico. Following the usual pattern, problems with longshore labor erupted in San Juan, and as a result commencement of this service was delayed several months. However, the beauty of this concept was immediately apparent. Since the highway vehicle was made up of easily separable units consisting of tractor, chassis, and container, the ship need only carry the latter, while the use of the wheeled highway components could be limited to the land segments of the system. So, the modern containership, and the concept of intermodal transport, was born.

The economics of the system were evident. When the ship is at sea, water transport is the cheapest of all. By handling a large unit load, high cargo-handling costs were overcome and port time drastically reduced. High cargo-handling productivity, combined with low per-ton-mile cost at sea, spelled success. The subsequent success story of Sea-Land is well known. After this successful coastwise venture, the company instituted an intercoastal service in 1962, and by 1966 had entered the foreign trade.

Matson Navigation Company

High cargo-handling and port costs also motivated Matson to look into containerization. This company, which operated a service between the West Coast of the United States and Hawaii, decided something had to be done to improve port productivity. In 1956, in a move uncharacteristic of the industry, Matson established an in-house research department to analyze their entire operation, with the objective of discovering possible improvements to the system that might solve their economic problems. Using sophisticated systems analysis techniques, including a computer fleet simulation model, they were able to test a wide variety of changes to the system. The study led to the adoption of containerization.

At this point Matson made a further departure from customary practices of steamship companies by setting up their own engineering department to develop the details of their container system. Like Sea-Land, Matson introduced the new system cautiously by carrying containers on the deck of conventional freighters. The success of this venture in 1958 led to the conversion of a C-3 type ship, the Hawaiian Citizen, to a full cellular containership. The ship went into service in 1960.

There were differences in the Matson and Sea-Land systems. Instead of the shipboard-mounted cranes used by Sea-Land, Matson developed special terminal cranes which could also be used to handle other types of cargo. In this particular aspect, the Matson system has become the general practice. A detailed analysis of the trade, as well as West Coast highway requirements, led Matson to adopt a 24-foot container size, differing from the industry trend.

With the technical aspects worked out, there was still the big question of labor acceptance. Fortunately, a satisfactory agreement was negotiated.

American Hawaiian Steamship Company

During this period (1957), American Hawaiian Steamship Company, which had withdrawn from the domestic trade but had money in its capital reserve fund, invested a large sum in a paper study of an intercoastal container system, including the complete design of a trailership to carry 538 thirty-foot trailers and a very sophisticated, completely automated terminal. After going so far as to build and test part of the automated system, the project was dropped for economic reasons.

Containerization in the Foreign Trade

The early pioneers in containerization, Sea-Land and Matson, were engaged in the domestic trades. The first attempt at large-scale containerization in foreign trade was made by Grace Line. In 1961, Grace converted two war-built, C-2 type ships, the Santa Eliana and the Santa Leonor, to full containerships for operation in its Caribbean service. These ships each had a capacity of 476 twenty-foot containers and were equipped with deck cranes. Unfortunately, this venture failed due to insufficient planning--principally the failure to obtain cooperation of longshore labor in Venezuela. The unions refused to handle the containers. This misfortune reverberated throughout the industry and was a severe setback for containerization, especially among the subsidized operators.

At about this same period, a West Coast operator, the American President Lines, also decided to test the concept. Two Sea Racer class ships, the President Lincoln and President Tyler, put into service in 1961, were built with one complete container hold serviced by a deck crane. The ships each carried 126 twenty-foot containers.

The Subsidized Ship Replacement Program

Just at the time the intermodal container concept began to blossom, a major ship replacement program by the subsidized operators was getting under way. During the period 1958-1965 approximately 130 new cargo liners of 23 different designs were contracted for and built. Under the operating subsidy agreements, operators holding such contracts were required to replace all their ships when they reached a statutory 20-year life. (New legislation subsequently changed this to 25.) All of these ships, with one exception, were conventional break-bulk cargo ships. The exception was the Magdalena class ships built by Grace Line for its South American trade. The four ships in this group were highly mechanized for cargo handling, including overdeck cranes for handling containers, sideporters, elevators, and conveyors for handling palletized cargo. The contracts for these ships had already been awarded before the Santa Eliana venture ended in disaster. Subsequent Grace designs contracted for a few years later provided little in the way of container accommodations, other than conveniently sized hatch openings for stowage in hatch squares. This represented the extent of recognition of containerization in a whole new fleet of U.S. cargo ships just as a new era in ocean shipping was dawning.

Apparently the success of the domestic operators in launching container services was overlooked by the

subsidized operators in foreign trade. In the late sixties the Maritime Administration made an effort to spur the introduction of containerization and other imaginative approaches to ship design when the Maritime Subsidy Board announced a new policy of making construction subsidy awards on the basis of obtaining the most ship productivity per dollar of subsidy, the productivity to be expressed in ton miles. A productivity formula was devised, and, while it was far from perfect, it did have the desired effect of steering the subsidized operators away from obsolete designs and into various forms of unitization.

The first big breakthrough among the subsidized operators in foreign trade occurred in 1966 when Sea-Land announced the inauguration of a weekly container service to Europe. This brought Sea-Land into head-to-head competition with the United States Lines, the dominant U.S.-flag operator in the North Atlantic. The reaction was swift. Two years earlier, in December 1964, U.S. Lines had contracted for the construction of five C-4 break-bulk type ships with some limited container capability for delivery in 1968. Shortly after the Sea-Land announcement, U.S. Lines, with MarAd approval, proceeded with a series of design changes on these ships already under construction, which ultimately resulted in their completion as jumboized full container ships. However, the delivery of these ships in 1968 left U.S. Lines two years behind the competition. The year 1966 proved to be the turning point. Since that time, up to the present, no conventional break-bulk cargo ships have been contracted for under the subsidy program. Even some of the newly delivered break-bulk ships, such as the APL Seamasters, were converted to full container ships. All of the new designs constructed in the period 1966-1977 were of the unitized type, either containerships, barge carriers, or RO/ROs.

Obviously, the planning process of the subsidized lines was something less than admirable. A detailed exposition of the planning process of some of the individual lines is contained in Reference 1. As pointed out in that analysis, not only had the advantages of containerization been demonstrated by two unsubsidized operators, but government-sponsored research studies published by the National Academy of Sciences in 1959 and 1963 demonstrated the economics of containerization in foreign trade and supplied a methodology for application to specific cases.

<u>Foreign Flag Acceptance</u>

By the late sixties, the container revolution was in full swing. What had started out as a U.S. innovation was quickly picked up by foreign-flag operators, and

containerships began to appear in most of the world trade routes. Currently, there are upwards of 500 full containerships in the world fleet, and an estimated 1 1/2 million containers. A recent Maritime Administration report lists 104 containerships under U.S. flag. Of these, 43 are in the Sea-Land fleet.

HARDWARE AND RELATED ELEMENTS

This section describes briefly the hardware and related elements of the intermodal container system. With everything undergoing continuing development, the term state-of-the-art is avoided.

The Ship

Concept. Perhaps the most remarkable phenomenon of container development has been the instant success of the initial ship design. The first all containership, the C-2 conversion that the Sea-Land Company put into service in 1958, was built with an internal vertical-cell type of structure and large hatches to utilize the "direct-drop" principle of cargo stowage. This basic idea proved to be so highly efficient that it has been universally adopted. It is rare, indeed, when a "first try" concept stands the test of time.

Configuration. In contrast to the break-bulk system, in which relatively small units of cargo could be accommodated in the "shaped" stowage areas of the ship, the containership must have "squared up" stowage spaces to accommodate the large unit loads (containers). To compensate for the resulting loss of internal space in the hull, the containership must carry a large proportion of its cargo above deck. Deck stowage accounts for a third or more of the cargo, depending on whether the boxes are stowed two, three, or four high. The extensive deck stowage has necessitated an increase in beam, and, in some cases, special ballasting arrangements to obtain the additional required stability.

Compared to the break-bulk ship, the depth of hull has also been increased substantially to accommodate the maximum number of containers below deck. Increased depth is the cheapest way to increase the internal capacity of the ship. Six-high stacking in the hold is fairly standard.

General Arrangement. A change in philosophy from the break-bulk era to give the cargo more consideration has resulted in locating machinery spaces in the finer part of the ship, in some cases all the way aft. There has also

been a trend toward locating the navigation bridge and crew accommodations toward the ends of the ship in order to provide maximum open deck areas for container stowage and handling.

Structural Strength. The direct-drop container handling method dictates very wide hatch openings, requiring concentration of longitudinal strengthening of the hull girder upper flange in a narrow stringer plate and sheer strake. For very large ships, it has been necessary to resort to a box structure built of longitudinally stiffened plates, and the application of high-strength steels. Another unusual structural problem arises from the heavily concentrated loads resulting from six-high vertical stacking of the containers. To absorb these loads, deep longitudinal girders with well-stiffened webs are provided in the inner bottom.

Cargo Handling. Most of the early container ships were built with their own shipboard-mounted cranes for load and discharge. As containerization developed, however, it became apparent that the place for the crane was in the terminal. Matson had made this decision at the outset. While the performance of the shipboard crane was technically satisfactory, the added weight and space did result in a loss of cargo capacity. With the gear ashore, this equipment is put under control of the people who use it. The gear itself can be better and more flexible, since the design does not have to be limited by the space and weight limitations of the ship or have seagoing qualities. Exposed machinery deteriorates very rapidly under sea conditions. The terminal crane can have a much higher utilization factor than the gear on the ship, which stands idle during the sea voyage. Crane operators in the terminal can acquire greater skill using the same machine every day than they could using different equipment on every ship that arrived at the dock.

Hatch covers are generally simple steel pontoons equipped with identical lifting fittings to those on the containers so they can be handled by the crane spreader. Cargo-handling rates are extremely high. Thirty or forty containers per crane-hour is a common rate.

Size and Speed. While there has always been a steady increase in size and speed of ships with time, the changes in the case of containerships have been spectacular. Ships with a capacity of 2000 containers (20-foot equivalents) and a speed of 30 knots are in service. The more common characteristics would be 1000-1200 containers and 23 knots.

This development has resulted in smaller fleets (fewer ships) to service a given trade route.

The Container

The intermodal container in use today evolved from the body of the over-the-road highway trailer used in the trucking industry. The important differences are the requirements that the cargo unit be separable from the wheeled chassis and be built with sufficient strength to withstand lifting and handling, as well as stresses imposed by stacking loads in the ship cell, ship motions, and sea action. Other important features include absence of protuberances and precise dimensional tolerances to permit smooth handling in the cell guides of the ship. Rail transport also must be considered. This usually reduces to providing sufficient strength in the end walls to withstand impact loads caused by car coupling. Lifting and securing fittings are also of great importance, since the handling rate and the security in transit are dependent on good design.

Many types of material have been used in container construction. Aluminum has been the overwhelming choice due primarily to its light-weight and anti-corrosion properties. Steel, plywood, plastics, and combinations of these materials have been used with success.

The intermodal container of today is the product of careful engineering analyses by the steamship lines, truck trailer manufacturers, and various standards committees, backed by experience gained from actual use.

A comprehensive discussion of container design is contained in Reference 2.

Size. The majority of steamship lines operating in foreign trade have adopted the 20-foot and 40-foot length with 8 foot width and 8.5 foot or 8 foot height, as originally recommended by both the American Standards Association (now the American National Standards Institute) and the International Standards Organization. Unfortunately, although understandably, the two domestic operators who started it all have stayed with their individual sizes. Sea-Land does provide some 40 capability in its newer ships in foreign trade.

Recently the term TEU (twenty-foot equivalent units) has come into common use to indicate container capacity.

Types. In addition to the common dry freight container, a number of special types have been developed and are in use. Of these, probably the most important is the refrigerated container. There are a number of versions in use, but one of the more popular ones has an electrically powered refrigerating unit recessed into the back wall of

the container. For over-the-road operation, current is supplied by an engine generator set mounted under the chassis. In the terminal and on shipboard the unit is plugged into a central power supply. Other special types include open tops, tanks for liquids, automobile carriers, and open trays. All of these types are circumscribed by a rectangular frame of standard dimensions fitted with standard corner castings to permit handling and stowage in the same fashion as the usual dry freight container.

Chassis. For highway operation, a skeletal chassis carries the container. It is essentially a light steel frame on which is fitted the fifth wheel for coupling to the tractor, and fittings for supporting and securing the container. Due to the construction of the container, the chassis does not have to furnish beam strength but must be sufficiently rugged to withstand braking loads and shock loads resulting from landing the container.

Carriage by Rail. For carriage by rail, the U.S. railroads have provided CFC (container on flatcar) cars. These cars, which are 89 feet long, are built with a cushioned undercarriage to absorb shock loads and are fitted with automatic securing devices which mate with the corner castings of standard containers. These cars will carry two 40-foot or four 20-foot containers.

Standardization. Any discussion or chronology of the development of intermodal containerization must include an account of the role of standardization. In 1956, when it became apparent that everybody planning to experiment with containerization was contemplating a different size of container, the Maritime Administration convened a meeting of U.S. steamship lines for the purpose of attempting to curb the proliferation of sizes, and, if possible, reach agreement on a limited number of sizes, at least for the subsidized fleet, so there could be some standardization in the ships.

Shortly thereafter, and before any consensus had been reached, the American Standards Association established Committee MH-5 for the same purpose, and Marad withdrew from the picture. This committee drew wide representation from the entire transportation industry and related industries. Subcommittees were formed to study dimensions, design criteria, testing, lifting and securing fittings, marking, etc. By 1959 agreement was reached on nominal dimensions. The standard consisted of a modular series with nominal lengths of 10, 20, 30, and 40 feet and a standard cross section of 8 feet by 8 feet. The lengths were based on the fact that 40 feet was the maximum length of trailer permitted on the highways in all 48 states. Ultimately, actual dimensions were assigned so that two of the 20-foot

size could be coupled and occupy the same overall length as one 40-foot, and, similarly, two of the 10-foot size could form one 20-foot unit. The width was dictated by U.S. highway limits and the height by rail tunnel clearances on the European continent.

Inevitably, when standards are established, some parties get hurt. In this case Matson, Sea-Land, and Grace Line had already made investments in other sizes. However, the standards were voluntary, and the committee felt that at this early stage the commitments made were not so great that a switch to the standards would be prohibitive. Grace Line did switch, but Matson and Sea-Land held to their original selections. In 1961 the International Standards Organization (ISO) entered the picture with the establishment of Technical Committee TC-104. This Committee acted rather quickly in endorsing the U.S. sizes. They also participated in selecting standards for other features on which the MH-5 Committee were already working.

The general reasoning behind the standardization movement was that only in this way could universal interchange be achieved and the full benefits of intermodal containerization realized. In an effort to support this philosophy, the Maritime Administration made adherence to the standards a requirement for obtaining construction subsidy or mortgage insurance for ships. (Subsequently, as a result of congressional hearings prompted by pressures from steamship companies using nonstandard sizes, this requirement was dropped.) To encourage containerization, the containers were declared eligible for mortgage insurance. With the exception of the two U.S. operators mentioned, practically all of the steamship lines in foreign trade have adopted the 20-foot and 40-foot sizes. In the intervening years since the standards were first established, a number of changes have been introduced. The 8 foot 6 inch height has been added as an alternate, and additional lengths, notably the 24-foot and 35-foot, have been included in the ANSI standard. In addition to dimensions, standards have been established for weight capacity, strength design criteria, test requirements, corner castings for lifting and securing, identification, and marking.

Standardization has led directly to the birth of the flourishing container-leasing business. Recent figures show that roughly one-half of marine containers and chassis are leased rather than owned.

Terminals

Terminals originally designed for break-bulk ships and boom-winch cargo-handling gear quickly became inadequate as the volume of container traffic grew. It was here, in the terminal, that big gains had to be made if the container concept was to pay off. The result has been that major general cargo ports have found it necessary to build new special container terminals. The principal features of these terminals are long quay-type berths served by rail-mounted container cranes and a large upland paved area for container storage. There is a lesser requirement for covered storage transit sheds, and these need not be adjacent to the docking area as in the break-bulk system. Also of major importance for a container terminal is easy access to major rail and highway networks.

As an example of a modern container terminal, Port Elizabeth serving New York and New Jersey covers 1165 acres of land, has three miles of wharf, 22 ship berths, and is equipped with 19 container cranes. Due to the large investment required, large-scale container operations have tended to become concentrated in fewer, large ports that can afford these facilities.

Handling Equipment. The primary item of container-handling equipment is the container crane. While there are many variations, the most common type is rail-mounted for positioning along the length of the ship, has a lift capacity of 40 tons or more, and an outreach over the ship of a hundred feet and a similar amount over the land. Most cranes handle containers with rectilinear motions in a plane at right angles to the ship. Large-capacity wheeled cranes have also been developed and are used in some ports to supplement the regular dock cranes during heavy demand periods or during emergencies.

In addition to cranes, a variety of wheeled equipment has been developed by manufacturers of materials-handling equipment to transport containers from storage areas to the crane hook and to stack them. Some operators prefer to store the containers on chassis which are then towed to the loading point by yard tractors. Others use straddle carriers or similar vehicles for yard handling. For very large operations, it has been necessary to develop computer-aided systems for controlling storage of containers awaiting shipment and planning ship loading to ensure stability and avoid overstow problems. The overall result is a great improvement in cargo-handling productivity over the old break-bulk system. Productivity thirty times the break-bulk rate would be a conservative estimate.

Longshore Labor

The threat of lost work opportunity caused the longshore labor unions to oppose the introduction of containerization, particularly in East and Gulf Coast ports. Attempts by the employers to reduce the gang size on the dock to the number of men actually needed to handle the containers was steadily resisted, so that potential labor cost savings could not be realized. Another obstacle to achieving savings was the matter of stuffing the containers. While this operation could be accomplished at much lower labor rates at consolidation terminals, the longshore unions insisted that this work must be reserved for them when the cargo originated in an area within 50 miles of the port. In 1964 the U.S. Labor Department made a study of container handling in the Port of New York and concluded that greater flexibility in gang size would be achieved through container handling. A special mediation board in 1964 recommended that the gang size for container handling be reduced from 21 men to 17. However, the unions continued to oppose any changes that would result in the loss of jobs.

A breakthrough in labor relations did occur on the West Coast. In 1960 an agreement was worked out between the Pacific Maritime Association, representing the employers, and the ILWU, representing labor, which reconciled the objectives of the employers and the union. This agreement, named the Mechanization and Modernization agreement, has brought a lasting peace on the West Coast labor front that permitted the steamship operators to get on with containerization. The men registered before 1958 were protected from loss of work, and the savings made possible by the mechanization were to be shared with them. Meanwhile, the situation on the East Coast has remained volatile. A prolonged strike over the container issue occurred in the latter part of 1977.

The Ship Operator

A shift from the old break-bulk system to a fully integrated shipper-to-consignee container service resulted in some major changes in the steamship operator's business. Under the old system, cargo was delivered to his dock in the home port, and his responsibility was limited to loading it on the ship, the sea voyage, and depositing it on the dock at the other end. The new system imposed an additional burden of arranging the land segments of the trip. In addition to operating a fleet of ships he must now also operate a large fleet of containers and chassis scattered throughout the hinterlands of the ports served.

The operation of a shipper-to-consignee container system requires a greater capital investment. The industry has changed from a labor-intensive to a capital-intensive operation. The cost of the ship is probably not greater than the break-bulk ship, since the added cost of container features such as cell guides and deck stowage fittings are largely offset by absence of 'tween decks, elimination of cargo-handling gear, and simpler hatch covers. The container ship, with its vastly improved port turnaround, is a much more productive ship. On the other hand, a great deal of capital must be invested in containers, chassis, and a variety of expensive handling equipment in the terminals.

INFLUENCING FACTORS

The basic purpose of this study is to identify the forces or circumstances that motivated the innovation and influenced the ultimate success. The preceding sections have been developed in such a way as to make the major factors self-evident. They are further developed in this section. Inhibiting factors are also discussed.

Motivation

There were three principal motivating forces present:

1. Economic--the cargo-handling crisis.
2. Competitive pressure.
3. Search for a better way.

The Cargo-Handling Crisis. As described earlier, the failure to improve labor productivity in the cargo-handling function in terms of both cost and time was bringing financial disaster to the shipping industry. Longshore labor productivity has remained static in the face of the postwar inflation in wages. The result was a substantial increase in the cost per ton of cargo handled and no improvement in port turnaround of the ship. Ships were getting larger and faster and also more expensive. Crew wages were also rising. Since the only purpose of the port stay is to load and discharge cargo, all of the ship costs while in port, including capital costs and crew wages, must be charged to the cargo-handling function.

The effects were first felt in the U.S. coastwise and intercoastal services. Except for some industrial carriers, this once-flourishing trade practically disappeared in the postwar period.

Other domestic services, notably Matson's West Coast to Hawaii trade, were also feeling the squeeze and were forced into looking for drastic remedies.

Competition. The source of competition was different for different trades. Domestic coastal and intercoastal services, while protected from competition from foreign-flag lines and U.S. subsidized lines, were in competition with truck and rail. The land carriers had done a better job in controlling costs, and the result was the demise of the water carriers in the pre-container era.

By adopting the intermodal container concept, Sea-Land reduced cargo-handling costs to the point where they could again compete.

In the case of the West Coast to Hawaii trade, Matson was faced with the hard choice between finding a way to reduce their port costs and charging their shippers higher rates. The latter alternative would have been an invitation for additional competition to move in, so they proceeded to investigate containerization.

As to companies engaged in foreign trade, the situation was somewhat different. Construction and operating subsidies put the U.S.-flag carriers on an equal footing with their foreign-flag opposites in a particular trade. Steamship conferences also tended to eliminate competition by the practice of pooling cargo and fixing rates. Foreign competitors on the same itinerary generally suffered the same high port costs. As long as everybody obeyed the rules of the game, competition was minimized.

The real competitive pressure which brought containerization to the foreign trade was apparently the appearance of Sea-Land, an aggressive unsubsidized operator, in the lucrative North Atlantic trade.

A Better Way. Many individuals are endowed with an inborn desire to improve their environment in some way and, consciously or subconsciously, are always analyzing processes or mechanisms with a view to discovering a "better way." In our country, it is frequently referred to as "Yankee ingenuity," although it has never been proven that Americans have any monopoly on this characteristic.

In the case of ship port operations as practiced in the 1940s, it did not require any great perspicacity even for a layman to observe that here was a broad area for improvement. The loading dock was a scene of congestion, disorder, danger, and back-breaking hand labor, a place that the Industrial Revolution had never reached. The situation was overly ripe for innovation.

Other Influencing Factors

In addition to the basic motivating factors, a long list of influencing factors that played an important part in the success of containerization can be recited. No attempt has been made to list the factors in order of importance.

Willingness to Assume Risk. Implementation of an innovation inevitabily involves risks--risk of capital and risk of reputations. In any endeavor, there are only a limited number of individuals and organizations willing to lay their money or their reputation on the line.

Fortunately, in the case of containerization, there were a few risk takers around--men like Malcom McLean, Stanley Powell, Frank Besson, and Lewis Lapham.

Research. While it cannot be precisely evaluated, there is little doubt that research played a significant part in the development of containerization. The following are a few examples.

a) Government-Sponsored Research. The Maritime Cargo Transportation Conference, the predecessor of the Maritime Transportation Research Board (MTRB), organized within the National Academy of Sciences at the request of the Departments of Commerce and Defense, published in the early 1950s a number of well-documented, authoritative studies on the economics of container transportation. The first of these, the S.S. Warrior, documented for the first time the cost in dollars, time, and man-hours involved in each of the seven segments of the maritime shipping system, thereby exposing the true port costs of the break-bulk general cargo system. Others of particular importance included the NEAC study, Maritime Transportation of Unitized Cargo, and Inland and Maritime Transportation of Unitized Cargo. These studies were particularly useful because they introduced a methodology for studying the system.

b) Matson. The decision by top management to establish in-house research and engineering departments led this company directly into containerization of their West Coast to Hawaii trade.

c) Technical Papers. A number of technical papers, published under the auspices of the Society of Naval Architects and Marine Engineers in the early 1960s, attracted attention to cargo-handling problems and the advantages of containerization; in particular, Competitive General Cargo Ships, 1960, and Ship Design for Improved Cargo Handling, 1962, can be cited.

d) American Hawaiian Steamship Company. While it eventually turned out to be only a paper exercise, the development of ship and terminal designs for an intercoastal container system undertaken by this company in 1957 provided useful information.

e) Pan Atlantic (Sea-Land). This was an important exercise carried to the point of producing complete plans and specifications of a RO/RO trailership. The information developed in this venture led to the abandonment of RO/RO in favor of the lift-on/lift-off system which has been universally adopted.

Ship Sales Act of 1946. This legislation, enacted in the early postwar period, enabled U.S. steamship companies to acquire good war-built ships at bargain prices. This was particularly beneficial to the unsubsidized operators, since it enabled them to buy and convert some of these ships to containerships with a minimum of capital investment.

Growth of Trucking. The growth of trucking at the expense of railroads in the United States probably had some effect on the development of the intermodal system. Just the effect of seeing so much cargo arriving at the pier in over-the-road trucks may have influenced the selection of the cargo unit of the trailer as the unit load for the integrated system. Also, a trucker was the original innovator of the intermodal system.

Interstate Highway System. The commencement of the construction of the federally-funded interstate highway system in the 1950s was a boon to long-distance trucking, making it the predominant carrier for the land segment of the intermodal system. This was the largest public works project ever undertaken by any government.

Interchangeability of Highway Equipment. The standardization of the "fifth wheel" coupling of chassis and tractor by the Truck Trailer Manufacturers to permit complete interchangeability of highway truck trailer equipment became an important ingredient of the intermodal system.

Standardization of Containers. The early achievement of standardization of the container under the auspices of ANSI and ISO was undoubtedly one of the most important factors in the rapid development of containerization. Convening a committee with worldwide representation provided a forum for the interchange of information and for spreading the gospel. Without standardization the feature of interchangeability is lost, and with it the dream of a "universal" system. The standards have been extremely beneficial, however, even though some operators have chosen to ignore them and go

their own way. Putting a check on the proliferation of sizes and standardizing structural requirements and lifting fittings have greatly facilitated the growth of the system.

Mechanization and Modernization Agreement. The agreement between the U.S. West Coast steamship operators and the International Longshore Workers Union which permitted the mechanization of terminal operations must be classed as one of the biggest factors in the development of containerization.

Extension of the Mortgage Insurance Provision of the Merchant Marine Act. Extension of the Title XI section of the Act to cover containers aided the spread of containerization by easing the capital financing.

The Marad Productivity Formula. The introduction by the Maritime Subsidy Board of a productivity formula as a basis for awarding construction subsidy funds contributed to the shift of the U.S. subsidized operators from break-bulk to unitized ship types.

Ancillary Benefits

While improved cargo-handling productivity was the principal attraction of containerization, the following other benefits accruing from the system have influenced the growth:

- Savings in packaging
- Improved customer satisfaction (better outturn of shipment)
- Reduction in cargo damage claims
- Reduction in pilferage

INHIBITING FACTORS

Offsetting the factors influencing the growth of containerization were a number of negative factors that tended to inhibit or delay containerization development. A few of these are discussed here.

Labor Union Work Rules

Longshore labor has had a long history of bitter opposition to the introduction of mechanization that carried the threat of a loss of jobs. This factor was particularly strong in ports like New York, which were plagued with a surplus of labor. In Bombay, an automatic grain loader rusted away on the dock while the longshoremen continued to

bag grain by hand as they had always been accustomed to doing.

Labor-Management Relations

Enlightened leadership on the part of both unions and management has been late to appear on the waterfront. Open warfare has been the order of the day, and strikes have been frequent and long. Industry-wide bargaining has yet to be achieved. The West Coast M&M agreement discussed earlier was the first big breakthrough.

Lack of Research and Planning

The level of research and planning in the steamship industry has been low compared to other industries. Several case histories of individual companies are discussed in Reference 1. Unless research is fostered and recognized at high levels in management, innovation is not likely to occur.

Conservative Management

Perhaps just because it is a very old business, steamship operation has been generally noted for its conservatism and traditionalism. This kind of atmosphere tends to stifle initiative and innovation. One illustration of this is the history of government efforts to promote higher ship speeds. In the late 1930s the Cimmarron class of tankers were built with additional power to give these ships the speed the Navy would need if the ships were to be utilized as fleet oilers. This additional power was paid for by the government as a defense feature, since the oil companies who operated them maintained they could not operate them profitably in commercial trade at the higher speed. Subsequently, however, it turned out that the operators did utilize the additional power and regularly operated these tankers at the higher speed.

A similar situation occurred in the case of the Mariner class cargo ships. As a result of the protestations of the subsidized operators that the 20-knot designed speed was uneconomical, the ship sale price was reduced to correspond to an 18-knot speed. Again, it was discovered that after going into service the ships were being consistently run at the 20-knot speed and, to a man, the purchasers agreed to buy the additional power.

Steamship Conferences

Membership in "conferences" is quite common in the foreign liner trade. The conferences do bring stability to the business by establishing pooling arrangements and standardizing tariffs, but by so doing tend to stifle competition and therefore innovation. The early reaction of the conferences to containerization was to charge premium rates for this mode of shipping.

Capital Investment

The greater capital investment required to operate a large-scale intermodal container system must be considered as an inhibitor. On the other hand, this factor could be changed from negative to positive for a company that has sufficient capital.

Government Subsidy

Subsidies to the shipbuilding and shipping industries authorized by the Merchant Marine Act have the merit of putting the U.S. operator on an equal footing with his foreign competitor while maintaining the high standard of living for his employees. However, they do extract a price in the form of restrictions such as a limit on profit, which adds to the difficulty of attracting investors. They also have a tendency to act as a crutch to inefficient management.

Government Regulation

Rehandling of cargo from one vehicle to another at the waterfront, which occurred in the break-bulk system, provided an ideal situation for customs inspections. Under the new system the loaded container can be transferred from one transport mode to another without disturbing the contents, thus limiting the opportunity for customs examination.

Tariffs for land transport are regulated by the ICC, and for water by the FMC, so that both agencies must be dealt with in the intermodal rate-making process.

Inadequate Port Facilities

The development of containerization was inhibited in certain undeveloped areas of the world served by ports with only primitive handling equipment and transport vehicles.

Shipper Education

General lack of an adequate program for educating the shipper on the advantages of containerized shipment has probably been a deterrent to the growth of the shipper-loaded container mode.

THE FUTURE

In a recent paper an official of Matson, one of the early pioneers in container shipping, warned that the Golden Era of containerizaiton is over. The big, early gains realized from the new technology have been partly overtaken by inflation, and the cost of capital has replaced port costs as the big economic factor.

The containerization experiment is now some 20 years of age. There is no doubt that it has found worldwide acceptance. But, are we better off? Has it brought long-run benefits or are we back where we started? Have we merely improved one economic factor at the expense of another? The answers to these questions are not easy to come by. Intuitively, one feels that progress has been made. Proving it with numbers is difficult.

Certainly, from a technological viewpoint, intermodal containerization is a success and it would be difficult to imagine going back to the old break-bulk system. The intermodal system providing "shipper-to-consignee", "door-to-door" service is a much more orderly, logical system. It is "a better way." The huge capital investment that has already been made in ships, containers, and specialized terminals would alone virtually rule out any turning back.

The growth of containerization in some trades has been nothing short of phenomenal. Figures recently obtained from the Port Authority of New York and New Jersey show that 75 percent of all general cargo passing through this port is now containerized. Approximately 70 percent of the vans are shipper loaded. They are also confidently projecting future growth as indicated in the following figures:

	*Number of Containers TEU	Long Tons
1975	1,750,000	11,680,000
1976	2,040,000	13,100,000
**1977	2,000,000	13,000,000
1978 (est)	2,250,000	14,500,000

*Includes RO/RO
**Longshore strike

The first 20 years featured hardware development. It is likely the future gains will come more in the area of organization and management streamlining the system, particularly the intermodal aspects.

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A FEDERAL DEMONSTRATION PROJECT: N.S. SAVANNAH

John G. Wirt

In 1955, the Eisenhower administration announced a plan to build the world's first nuclear-powered merchant ship, as part of the U.S. Atoms for Peace program. This ship was later called the N.S. Savannah, after the first steam-powered ship to cross the Atlantic ocean. Like its steam-powered predecessor, the N.S. Savannah had a history of mixed successes. Because of development problems, it was launched later than originally planned. No sooner were the shakedown cruises completed than it had to be detained in port for a year because of a union dispute. Success finally came in a series of demonstration voyages over the next two years to ports around the world. Large crowds came aboard at each stop to see this purported ship-of-the-future. But in subsequent service as a general cargo ship, the N.S. Savannah cost considerably more to operate than could be earned in revenues, casting doubt on the idea that nuclear-powered merchant ships could be commercially successful.

In 1970 the ship was retired and given to the city of Savannah, Georgia, as a memorial to President Eisenhower. The total cost of the N.S. Savannah to the federal government had been over $100 million, and the Maritime Administration still has to pay a small amount each year to provide safeguards against some radiation hazards.

DEMONSTRATION GOALS

Whether the N.S. Savannah was a success or not depends on how one views its purposes. As a "peace" ship, the N.S. Savannah helped to pave the way to using the atom for commercial purposes. It demonstrated that nuclear power could be safely applied for practical purposes and provided valuable experience in developing workable safety measures. As a "merchant" ship, the N.S. Savannah was not successful and probably set back the introduction of the innovation of a nuclear-powered merchant marine for many years. These two different purposes, as well as many constraints, were

imposed on the N.S. Savannah project by the exigencies of the political process. The ensuing compromises that had to be made in the ship's technical design rendered it less suitable for either purpose than it could have been and led to a series of events that even obscured the successes that were achieved. The technical experts realized the difficulties, but saw the N.S. Savannah project as a wedge in the political process that could be capitalized upon to build the technological and institutional base for a nuclear-powered merchant marine.

President Eisenhower's original concept was to build a ship that could sail around the world to dramatize the harnessing of the power of the atom for the benefit of mankind. His goal was to change the prevailing image that nuclear power was mainly an instrument of war. The White House saw, and there was further testimony in Congress by Admiral Rickover and others, that the technology was not yet available for the ship to be a demonstration of the commercial feasibility of nuclear propulsion for merchant ships. Advancing the idea that the atom could be used for peaceful purposes, whether to propel a ship or to generate electric power, was the overriding initial need.

It was suggested to the White House that the quickest way to get an atomic-powered ship to sea would be to install a spare reactor from the Navy's development program that had just produced the U.S.S. Nautilus submarine. No other reactor existed that was even remotely suitable for installation in a ship; any other approach would require a major research and development effort. Using a reactor developed by the military for defense purposes, however, was inconsistent with the concept of a "peace ship"; moreover, its use might set a precedent for military control by the federal government, not only in nuclear power for merchant shipping, but also in other applications. For these reasons, the Eisenhower Administration was reluctant to use the spare U.S.S. Nautilus reactor, even though it offered the simplest solution. More important was the need to establish the institutional precedent (which the N.S. Savannah eventually did help to achieve) that there should be civilian control of nuclear programs for civilian purposes. Part of the institutional change was to gain declassification of the necessary technical knowledge, then tightly held by the military.

Chairman Bonner of the House Merchant Marine and Fisheries Committee and other Committee members supported the President's idea of building an atomic ship, but for a different purpose--to take the first step toward a commercial fleet of nuclear-powered merchant ships. The Committee thought that a nuclear fleet could return the decaying American merchant marine to the eminence over the

fleets of other nations that it had decades earlier. The testimony of Admiral Rickover and others that the Navy reactor would be extremely expensive to operate in a merchant marine application convinced the Committee that a new reactor should be developed that would be as economically efficient as possible, even though this would require more time and expense than the Administration had planned. Time was a critical factor because the Atoms for Peace initiative, for which the ship project had been conceived, was developing rapidly. Chairman Bonner criticized the administration's proposal as a plan for building a "...sideshow ship, or a carnival ship, or a Mississippi riverboat."

Another major obstacle for the nuclear-powered ship project was conflict between the Merchant Marine and Fisheries Committee on the one hand and the Joint Atomic Energy Committee on the other. The Joint Atomic Energy Committee had complete jurisdiction over all activities of the federal government in atomic energy, which hampered the efforts of the Merchant Marine and Fisheries Committee to promote a nuclear-powered merchant marine. Members of the Joint Committee testified in the House of Representatives against the efforts of the Merchant Marine and Fisheries Committee to pass a bill authorizing the construction of a nuclear-powered ship. The White House had to make special overtures to the Joint Committee, which finally paved the way for passage of a bill.

TECHNICAL DESIGN

The bill was finally signed on October 15, 1956, nearly 1 1/2 years after the President's initial announcement of his plans. The President's statement accompanying his signature of the bill clearly showed the shift that had occurred during the negotiations with the Congress, from an objective of building a peace ship to one of building a "...floating laboratory, providing indispensable information for the further application of atomic energy in the field of ocean transportation." The House Senate conference report stated the new purpose even more strongly in specifying that this "...first experimental application of nuclear power should be a <u>practical</u> merchant vessel of <u>combination passenger and cargo design</u>, and that a new reactor of the most advanced design possible for a practical merchant ship should be developed" (emphasis added). This new objective was a technological contradiction. Responsibility for managing the design, construction, and operation of the ship was assigned to a joint project of the Maritime Administration and the Atomic Energy Commission.

The technical experts in the Maritime Administration had argued that a large, bulk freighter or tanker would have provided a much more economical vessel. The White House directed that, to be useful as a peace ship, it had to be sufficiently small to enter municipal harbors around the world and carry passengers. An all-passenger ship could have been designed, but that would have been prohibitively expensive to build because of the cost of providing accommodations.

The compromise was to build a small, combination passenger and general cargo ship, even though it was clear that the resulting vessel would not be commercially efficient in either service. The design was to modify a standard Mariner-class freighter hull to accept a reactor and to provide for passengers. Additional compromises in outfitting the ship to give it a more streamlined and pleasing appearance further reduced its efficiency in cargo service.

Development of the propulsion system and safety measures required solutions to many technical problems. A decision was made to build a low-enriched, pressurized-water reactor, because it offered the best operational characteristics, even though no prototype had ever been built. The U.S.S. Nautilus-type reactors and the Shippingport demonstration of a reactor for central-station electric power generation provided some operational experience and technology but were differently designed. Other central power station reactors were under development at the time, but they were much larger than what was needed for the N.S. Savannah and had not been operated commercially. The state of knowledge about small, low-enriched reactors was so crude at the time that the development contractor discovered that if they had followed their initial design specifications they would not have been able to make the reactor go critical. Nevertheless, a reactor was produced that worked well, even though a substantially longer development period was required than was originally planned. Contrary to conventional R&D practices, no prototype was built; the only model constructed was installed in the N.S. Savannah--a step for which the project team was heavily criticized by the Navy.

Further difficulties were encountered in finding a shipbuilder, since all the yards with nuclear experience were booked by the Navy and did not bid on the Savannah project. The shipyard eventually chosen had no nuclear experience and furthermore was in bankruptcy. This meant that the N.S. Savannah project team literally had to lead the shipyard through the process of building a nuclear ship, a far more intricate and exacting process than building a conventional ship. This was another way in which the lack

of nuclear technology in the associated industry delayed the project.

DEMONSTRATION OPERATIONS

After launching N.S. Savannah in early 1962, the team began to run into labor problems, partly because of the implications of nuclear-propulsion for the crew and partly because of unrelated political conflicts among the unions involved. The first firm selected by the government to operate the ship had contracts with separate unions: deck officers were members of the International Organization of Masters, Mates, and Pilots, which was aligned with the National Maritime Union (NMU), whereas the engineers were represented by the National Maritime Engineers Beneficial Association, which was aligned with the Seafarers' International Union (SIU). Because of the technical knowledge required to operate a nuclear-powered ship, the engineers wanted to be paid more than the deck officers, whereas on conventional ships deck officers had always been paid more. Also, the SIU and the NMU were bitter rivals. The impasse was not broken until a year later when the Secretary of Commerce finally canceled the first operator's contract and contracted with another one in which both the deck officers and the engineers were members of the same union. Meanwhile, the N.S. Savannah had to be taken out of service and was tied up in port. These labor problems turned nearly everyone against the N.S. Savannah, from Chairman Bonner to President John F. Kennedy. Kennedy and his Secretary of Commerce had to deal with the problems and did not have the same commitment to the ship that Eisenhower had shown.

During the next year, the N.S. Savannah cruised around the world, visiting many ports so people could come aboard for trips and view the new ship for themselves. These voyages were a great public relations success for the United States, although they were somewhat too late to make a significant contribution to the Atoms for Peace initiative because of the delays that had occurred.

Subsequent to its demonstration cruises, the N.S. Savannah was operated under charter for an additional 5 years as a general cargo ship in regular commercial service. At this stage the design compromises and technical shortcuts that were made in building the N.S. Savannah came to the surface. The reactor worked well, but the ship was not a good freighter. The passenger compartments and the swimming pool became wasted space when they were closed off; the winches and other freight-handling gear were too light; and crew turnover was high. All of these problems increased the costs of operation compared to a conventional ship.

Revenues from the N.S. Savannah's operations failed to approach the direct and indirect subsidies that were provided to maintain operations. (The federal government gave the N.S. Savannah to the charter company for $1.00 a year.) Then, despite the expenses of the ship operations, the Johnson administration was prevented from withdrawing the ship from service by Congressional outcries.

A futile search began for a better use of the ship. And, compounding these difficulties, Congress required the Maritime Administration to fund the substantial operating costs from its small R&D budget. All of this contributed to a general perception in many quarters that the N.S. Savannah had been a failure. Long forgotten were the reasons why it was built and why it was not the ship that it could have been. The lessons are twofold: politics and the commercial application of new technology do not mix well, and a technology should be well in hand before being sold as ready for commercial application.

SECOND-GENERATION DEVELOPMENT

Throughout the period when the N.S. Savannah was being developed, and during the initial years of operation, the N.S. Savannah project team was actually working behind the scenes to develop much more advanced reactor designs and study efficient applications of nuclear power to merchant shipping. Using the base of popular support initially created by the N.S. Savannah project, the team wanted to proceed with the development of a second-generation fleet of ships that would be much closer to the commercially successful vessels that had been envisaged. A much-improved reactor was eventually developed and tested. Design studies showed that for nuclear ships to be commercially successful they had to be (a) much larger than any ships then on the seas, (b) dedicated to a highly specialized service like bulk transport or containerized freight, an innovation that was only beginning to be introduced at the time, (c) operated at high speeds, and (d) built in fleets rather than singly, and with their own port facilities. All these features together were necessary to offset the much greater capital cost of a nuclear-powered ship as compared to a conventional one.

But each requirement implied a major innovation in merchant shipping. (For example, hulls weighing several hundred thousand tons--the required range of efficient nuclear-powered ships--have not been built until recent years.) Consequently, attempts to convince the administration and the Congress on building a fleet of second-generation ships fell on deaf ears, and then the N.S. Savannah's problems further clouded the picture. The

second-generation reactor has been used in the nuclear-powered merchant ship built by the Germans and also in the one built by the Japanese. There have also been some land-based applications. Because many of the innovations seen by the N.S. Savannah team as necessary to the successful merchant shipping application of nuclear power have not become realities until recent years, it appears that, while the visions of the team were correct, they were probably premature by at least a decade. Current studies of nuclear-powered merchant ships recommend the same kinds of design features for commercial feasibility and are beginning to indicate that the gaps in the development of ships that would be commercially profitable can be bridged.

PROJECT RESULTS

Despite the difficulties encounted by the N.S. Savannah project, results were achieved in both advancing technology and developing an institutional base for nuclear-powered merchant shipping that should be more widely recognized. Technical contributions were the reactor, which provided valuable design experience; the safety and containment systems, which worked well and showed how costs could be minimized; and the crew training program, which showed that regular merchant seamen could be trained to operate a nuclear ship. The institutional effects were (a) the experience that was gained in working with foreign governments and federal agencies to establish port safety requirements and clearance procedures; (b) the precedents set in negotiating agreements on liability with foreign governments; (c) the contributions, however difficult to trace, to declassifying nuclear technology; (d) the precedent of having Congressional committees other than the Joint Atomic Energy Committee oversee nuclear projects; and (e) possibly some encouragement given to operators and unions to accept higher levels of ship automation. (Ships with automated control rooms have been built since, whereas before the N.S. Savannah, there were none.) Additionally, the N.S. Savannah provided some valuable baseline data for setting insurance rates for nuclear-powered ships. However, the labor problems that plagued the N.S. Savannah were apparently not solved. Equally important, the high costs of the project still have lingering effects.

THE NATIONAL SHIPBUILDING RESEARCH PROGRAM:
A CASE STUDY OF INNOVATION IN THE MARITIME INDUSTRY

Linda L. Jenstrom

During the past two decades, increasing attention has been given to examining the process of industrial innovation and technological change. The federal government has sponsored a variety of projects and programs in an effort to stimulate the innovative process in both defense and non-defense industries. Although the results of federally supported research and demonstration efforts have generally been mixed, one project, the National Shipbuilding Research Program, has achieved substantial gains.

The achievements of the National Shipbuilding Research Program are particularly impressive because the program focuses on a sector of the maritime industry that traditionally has had few of the characteristics usually associated with ongoing technical change. The shipbuilding industry has been forced to cope with a slow growth rate, unstable market demands, heavy capital investment requirements, low investment returns, and a high rate of staff turnover. Such conditions usually foster security-seeking behavior, not risk-taking. Consequently, an analysis of the positive impact of the National Shipbuilding Research Program on the climate for and rate of innovation within this industry is of particular importance.

The National Shipbuilding Research Program is a collaborative effort of the federal government and the shipbuilding industry. The program is unique in that it is founded on the premise that innovation and technological change can best be fostered when research is undertaken as a joint venture of government and industry. The objectives of the program are to improve the productivity of the shipbuilding industry and to reduce government subsidies to the industry.[5] Since its inception in 1971 (through FY 1978), over 125 projects have been funded by the government, at a cost of $21 million. The industry has contributed approximately $8 million to these projects in the form of manpower, materials, and facilities.[8] The National Shipbuilding Research Program has been judged highly

successful in an independent comparative study of federally funded demonstration projects,[1] and in both formal[2] and informal assessments[5] conducted by the program participants.

A careful examination of the genesis and development of this program yields a considerable amount of useful information about the innovative process within the maritime industry. On one level, the program itself can be viewed as an innovation. It embodies a new philosophy, has an unusual management design, and is without precedent in the history of U.S. government-maritime industry relations. On a second level, examination of the way the National Shipbuilding Research Program functions provides a unique perspective on the innovative process. The program exists to create and ensure the use of new technologies in shipyards. Thus, analysis of the mechanics of the program, its successful and unsuccessful projects, and the programmatic changes that have taken place sheds light on the factors that can inhibit or encourage technological change.

Finally, the National Shipbuilding Research Program has helped create a new environment within the shipbuilding industry. Many of the barriers to change that existed in 1970 have been substantially reduced. New opportunities for intra- and inter-industry cooperation have been opened. The credibility of the federal government has been enhanced, and there is new recognition of the importance of the shipbuilding industry to the U.S. maritime industry as a whole. To understand the impact of the National Shipbuilding Research Program, it is necessary to begin with a look at the conditions prevailing in the industry at the time the program was founded.

TIME FOR A CHANGE

As the decade of the sixties drew to a close, there was widespread recognition of the need for substantial changes in U.S. maritime policy. Significantly, the thrust toward a new approach to the problems plaguing the shipbuilding industry can be traced independently through the political sphere, the private sector, and the U.S. Maritime Administration (MarAd). It may be that the initial success of the National Shipbuilding Research Program was a product of convergent and complementary political, private, and bureaucratic aims.

The Economic Environment

The post-World War II decades brought a steady decline in the economic strength of U.S. shipyards. In the years immediately following the war, over 7 million deadweight

tons of ships were sold by the U.S. Maritime Commission (now the U.S. Maritime Administration) to U.S. operators at bargain-basement prices.[7] Consequently, orders for new construction were few and far between. Further, U.S. operators, unlike their foreign counterparts, adopted a policy of depositing capital in construction accounts as a hedge against future needs for replacements or repairs. Foreign operators continued to reinvest capital in new ships that secured competitive advantages through innovations in design and equipment. Unfortunately, orders for new ships generated by foreign operators generally went to foreign shipyards since cost differentials effectively excluded the U.S. yards from realistic competition.[3] Thus, both the U.S. merchant fleet and the U.S. shipyards fell further and further behind their foreign counterparts.

At the end of World War II, there were 57 U.S. shipyards actively building ocean-going vessels. By 1970, there were only 14 major U.S. yards.[6] These 14 yards can rightfully be called the survivors. These were the yards that were able to limp along on the sporadic orders generated by U.S. operators, the Navy, and other branches of the government. In general, the orders fluctuated as the international scene fluctuated. For example, the Korean War, the closing of the Suez Canal, and the Viet Nam War brought temporary increases in the market demand for new ships. Unfortunately, each increase was closely followed by a fairly precipitous drop.[4] Without a predictable and stable workload, shipyard managers had little incentive or opportunity to improve their facilities. The erratic market was not conducive to the development of a planned production approach or to the maintenance of a stable, skilled work force.[6]

The downward spiral of the U.S. maritime industry is well documented. By 1970, the U.S. merchant fleet was no longer among the top five fleets in the world. There were low returns on industry investment, and U.S.-flag vessels carried an ever-declining share of world trade. Although U.S. foreign trade had been steadily increasing, rising from 120 million tons in 1950 to 470 million tons in 1970, the U.S.-flag share of this market had dropped from 53 percent to 6 percent during the same period.[4] Clearly, the provisions of the Merchant Marine Act of 1936 had proven unequal to the task of supporting either an adequate shipbuilding industry or an adequate U.S. merchant fleet.

The Merchant Marine Act of 1970

By 1970, political inaction was no longer a defensible position. Some argued the urgent need to pass legislation that would revitalize U.S. maritime interests. Others held that the federal subsidy program should be dropped entirely.

When the dust settled, the nation had a new legislative mandate known as the Merchant Marine Act of 1970. As proposed by President Nixon and, ultimately, passed by Congress, the 1970 Act was the first major overhaul of national maritime policy in three decades.

The Act affirmed the importance of merchant shipping to the welfare of the country. It provided for ten years of federal support to both the shipbuilding and the ship operating industries. It extended subsidy payments to non-liner services and authorized negotiated contracts between operators and builders, with subsidy payments going directly to the builder. The Act also expanded the existing authorization for federally supported research and development efforts.

Prior to passage of the 1970 Act, there was no technical program within MarAd to support the shipbuilding industry by conducting research aimed at identifying less costly and more efficient ways of constructing ships. The 1936 Act had, however, provided authorization for federally sponsored research projects conducted in collaboration with ship operators. Such projects were generally aimed at improving ship design, ship machinery, and cargo handling. As the provisions of the 1970 Act were being formulated, MarAd officials worked to have the 1936 authorization expanded to include the shipbuilding industry. The Act, as passed, specifically included shipbuilders, thereby giving MarAd the authority to launch a new program. Further, the President's message which accompanied the act explicitly supported the establishment of a cooperative research and development program. The message called for an enlargement and redirection of maritime research programming with a greater emphasis on practical applications and coordination with industry.[10]

MarAd was given responsibility for implementation of programs designed to enable the industry to meet the objectives of the 1970 Act. These objectives were quite specific. Plans called for the construction of 300 new ships in ten years. The proposed building program was valued at about $6 billion, with approximately $2 billion provided by the government in the form of subsidies. In an effort to stabilize the industry and assist in the development of long-range planning, MarAd undertook a variety of projects. Among these was the development of a new program of shipbuilding research to be conducted in partnership with the industry. The new program was christened the National Shipbuilding Research Program.

The Maritime Administration (MarAd)

The National Shipbuilding Research Program was not an afterthought. In the late 1960's a new concept of research and development management had begun to emerge in the Office of Advanced Ship Development (OASD), a division of the Office of Commercial Development of MarAd. The premise was that development projects should not be initiated without a realistic measure of industry interest in the potential results. In the latter months of 1969, a proposal for the formation of an industry council to advise MarAd on research and demonstration projects was presented to the Maritime Administrator by J.A. Higgins, who was then the Director of OASD, and J.J. Garvey. (Mr. Higgins is now Deputy Director of the Office of Commercial Development, and Mr. Garvey is Director of the Shipbuilding Research Program Office.) The Maritime Administrator lent his support to the developing plan.[10]

With shipbuilding specified in the authorizing legislation, and with the general reorientation of federal non-defense research and demonstration efforts, the OASD staff felt that it could move forward with a clean slate to implement a program that would be truly responsive to the needs of shipbuilders. A basic philosophy of the new program was an attempt to avoid previous errors committed in the name of maritime research and demonstration. In particular, the OASD staff was determined to fund only those projects that could and would be used by industry.[10]

The task of designing and implementing a viable industry-government collaborative research and demonstration program was formidable. The first step was to define the program. It was concluded that, to be in compliance with the intent of Congress and the President, the program must emphasize practical applications and be conducted in close cooperation with the shipbuilding industry. Further, the projects sponsored by the program should be (a) of a scope and nature to require cooperative development; (b) directed toward reducing government subsidies as well as shipbuilding costs; (c) of a near-term nature; (d) limited to improving the shipbuilding process; and (e) supported through cost-sharing between government and industry.[5]

The second major step was to find a means of ensuring that the new program would be truly a joint venture between government and industry. There were few, if any, precedents. In particular, a reliable means had to be found of bringing together industry representatives and ensuring that they, not the government, defined the program's research objectives. OASD staff felt that it would be advantageous to cooperate with an existing group of industry

representatives, since such a group would be more likely to be self-directed.

A search began for an appropriate group to represent the managerial and technical views of the industry. The selection was critical, since the group was expected to participate actively in all aspects of the technical management of the program, including setting priorities, assigning responsibility for projects, providing technical direction, and assisting in arranging appropriate demonstrations. In addition, it was important that the group selected be characterized by inclusivness; that is, the group should be open to individuals with a vested interest in the industry and with valid reasons for involvement. After exploring several alternatives, the ideal candidate group emerged--the Ship Production Committee of the Society of Naval Architects and Marine Engineers (SNAME).

SNAME: The Ship Production Committee

The founding of SNAME's Ship Production Committee provided the final link in the convergence of political, administrative, and private industry interests that led to successful launching of the National Shipbuilding Research Program. Established in 1893, SNAME is a professional association with approximately 14,000 members. In 1939 SNAME started a Technical Research Program to provide limited funding for selected projects in a variety of areas. SNAME's Technical Research Program now includes projects focused on marine systems, hull structure, hydrodynamics, ship machinery, and ship technical operations.[9] Notably, prior to 1969, SNAME-sponsored research projects did not include ship production as an area of interest.

In 1969, a group of ship production engineers and managers sought to remedy this omission by establishing a forum within SNAME specifically for professionals involved in ship production. The group was displeased by heavy public criticism of the industry and keenly aware of the growing discrepancy between the technical capabilities of American and foreign shipyards. It was interested in finding ways of expanding the technical knowledge base and developing new solutions to the problems mutually faced by all of the shipyards. The members of the group felt that shipyard engineers should be working with ship operators in designing new vessels, rather than simply receiving specifications from naval architects. The low status of ship production engineering in the maritime hierarchy was evidenced, the group felt, by the lack of a technical committee for specialists in ship construction. The formation of a Ship Production Committee in SNAME was urged.

The proposal received strong support from top-level shipyard management and was formally approved by SNAME in July 1969.[10]

The newly formed Ship Production Committee had several characteristics which were destined to contribute substantially to the success of the National Shipbuilding Research Program. Its membership predominantly consisted of senior technical and managerial personnel from the shipbuilding industry. It included representatives of the Coast Guard, the Navy, MarAd, and the American Bureau of Shipping. In addition, the Ship Production Committee was less than six months old and had not yet established a firm operating program. Finally, it was organized under the auspices of a recognized and prestigious professional society, and had the support of most U.S. shipbuilding firms.

THE OBSTACLE COURSE

Although there were significant factors stimulating the evolution of the National Shipbuilding Program, there were also significant barriers to its implementation and subsequent functioning. In the course of its seven-year operation, some of these barriers have been reduced or eliminated. Others are targets of new programming efforts, and some are beyond the realistic scope of a technical development program.

Industry Competition

In 1970, there were a number of obstacles to establishing the new program. One of the most significant obstacles was the nature of the industry itself. Shipbuilding was, and still is, a competitive industry. Personnel, particularly production personnel, were actively discouraged from sharing their information or expertise with competing firms. The lack of any formal professional group for production personnel had effectively limited the development of a sense of camaraderie and mutual interest. It is important to note, however, that the Ship Production Committee was founded independently and in advance of MarAd's efforts to establish a cooperative program with the industry. Although the shipyards were still reluctant to abandon their long-standing competitive practices, the economic realities of the late 1960's underscored the need to explore new approaches to the practical problems of ship production. As the program progressed and the financial and practical advantages of cooperative action were demonstrated, the yards gradually modified their competitive

stance. The identification of solutions to mutual problems came to be viewed as a mutual advantage.

Industry Priorities

A second major obstacle to the new program was the low priority given research and demonstration efforts within the shipbuilding industry. On a national level, studies showed that shipbuilders spent less than one-quarter of one percent of their annual revenues on developmental research.[5] Factors contributing to this low level of interest in research included the potential cost of downtime due to failure of experimental systems, the cost of insurance to cover direct losses and consequential damages during tests, and the potentially small profit to be derived from an innovation.

The new program allowed MarAd to assume the impact of many of the risks associated with technical research and demonstration. Although the program is based on government-industry cost sharing, the government provides funds for all direct costs; industry provides facilities and overhead costs.

Government Credibility

A third major obstacle was that the industry tended to take a dim view of the effectiveness of government-sponsored research programs. During the initial series of meetings between OASD staff and the Ship Production Committee, members of the committee were skeptical. There was a general feeling that the OASD staff was not proposing anything new and that the program would collapse after a short time. There was doubt that the government really wanted advice. Rather, it was assumed that the new program was simply a marketing strategy designed to sell industry on a preconceived plan for technological improvement.[10] Finally, should the program succeed, the industry representatives felt that OASD would use the success to increase its own share of the MarAd budget and ultimately assert total control over the program. The concept of bureaucratic empire-building was all too familiar to the shipbuilders. The OASD staff went about overcoming this mistrust in the only practical way, through concrete demonstrations of their intent to ensure that the program was responsive to the industry and cooperatively managed.

Legal Issues

The atmosphere of suspicion surrounding the initial meetings held to discuss the new program was heightened by the traditionally adversarial role of MarAd vis-a-vis the industry. The MarAd subsidy program had a history of contract disputes that had strained government-industry relations. Further, many of the yards had recently been charged by MarAd with violations of the Equal Employment Opportunity regulations. Finally, the shipyards were wary of running afoul of the government's antitrust laws.

On the strength of the changes in the Merchant Marine Act of 1970 and the public statements of the administration outlining the need for cooperative research and development programs designed to increase the technological capacities of industry, the spokesmen for OASD set about persuading industry representatives that the new program was not a violation of antitrust laws. OASD staff visited the top executives of all the shipyards to discuss the new program. During the course of these visits, they explained that the program would not exclude any American yard from participation and that the prices of ships would not be discussed at any of the meetings. The OASD staff also explained that there were precedents in the law firmly establishing the right to exchange technical information in organizations that are a part of a professional technical society. Finally, the OASD staff argued that, in a joint effort, there would be a joint assumption of any legal risks. Following this series of meetings, all of the shipyards, with the exception of one, which stayed out of the program until 1973, began to participate more actively in the new program.[10]

Program Strategy

The program strategy employed to overcome these obstacles was straightforward. The strategy had four elements: (a) encourage the shipbuilders to define their common needs and outline projects with a potential for meeting those needs; (b) arrange for the projects to be housed within the industry itself; (c) provide mechanisms to ensure the joint management of the projects; and (d) encourage implementation of the results of successful projects. By May 1971, the first list of industry-generated projects had been developed, approved by the Ship Production Committee, and funded by MarAd. By mid-1972, all of the shipyards, save one, were increasing their active participation in the National Shipbuilding Research Program, and the preliminary results from the program were favorable.[10] Key to this early success was the unique way the program was organized.

ORGANIZATION OF THE NATIONAL SHIPBUILDING RESEARCH PROGRAM

The National Shipbuilding Research Program has three major components. Industry plans and program recommendations are generated by the Ship Production Committee and its technical panels. Government management of the program is carried out by the Shipbuilding Research Program Office, Office of Commercial Development, MarAd. Program execution is carried out by Program Managers housed within the shipyards responsible for the administrative management of specific program areas.

The Ship Production Committee

The first component, the Ship Production Committee, is composed of top-level shipyard managers. In general, they represent the production side of their organizations rather than the finance or marketing sides. Representatives from the Coast Guard, the Navy, and the American Bureau of Shipping also serve on the Committee. Specific research projects are generated by technical panels that operate under the Committee's direction. The responsibilities of the Ship Production Committee include providing policy guidance on the overall direction of the program to the technical panels and to the MarAd office and reviewing individual projects submitted for consideration by the technical panels. Projects approved by the Ship Production Committee are fowarded to the Shipbuilding Research Program Office for funding.

The technical panels are structured to address areas deemed important to the improvement of the ship construction process. They may be established or discontinued as needed. In general, the technical panels are composed of mid-level engineers with production experience. Each panel has between six and forty members, with one representative from each of the major shipyards serving on most of the panels. In addition, each panel has a MarAd representative and, if appropriate, invited representatives of relevant regulatory bodies.

The technical panels meet individually four to six times a year to discuss production problems and possible solutions, develop specifications for new projects, and review the status of ongoing projects. Annually, each panel forwards specifications and budget recommendations for new projects to the Ship Production Committee. The Committee may ask a technical panel to modify its proposals or may approve them without change. Approved projects are forwarded to MarAd for funding consideration. If funds are allocated, the technical panel is asked to participate in the selection of project sponsors and/or contractors.

Technical panels also act as advisors to Program Managers on technical issues arising in the course of project implementation.

The Shipbuilding Research Program Office (MarAd)

The second major component of the program is the Shipbuilding Research Program Office of MarAd. This office is responsible for government management of the program. The office is small, consisting of a director and one assistant and, therefore, has been able to maintain flexibility in dealing with the industry. The Shipbuilding Research Program Office has divided its budget into four major areas: facilities; manpower and motivation; ship producibility; and shipyard automation. In general, the technical panels are grouped under these headings as shown in Figure 1.

The annual list of approved projects, with technical and economic justifications, is fowarded by the Ship Production Committee to this office for review. The recommended projects are evaluated on the basis of economic and technical criteria, and priorities are established. The recommendations, or portions of them, are then submitted to the Maritime Administrator for approval within limits of the available budget. During the first seven years of the program, approximately 75 percent of the projects submitted by the Ship Production Committee were approved by the Maritime Administrator. In addition, two programs were terminated on advice of the Ship Production Committee.[8]

Program Managers

Under the joint direction of the Ship Production Committee and the Shipbuilding Research Program Office, individual shipbuilding companies take responsibility for implementing groups of approved projects addressing specific areas. Projects are carried out under a cost-sharing contract negotiated between MarAd and the sponsoring company. Two criteria are used to select sponsoring companies. First, the company must be recognized as having a high level of technical expertise in the subject area. Second, the company must demonstrate a strong commitment to carrying out research under the guidance of the Ship Production Committee. This commitment is usually demonstrated by the willingness of the company to shoulder at least one-third of the cost of the program. At present, there are six companies acting as primary sponsors and three acting as secondary sponsors. These companies are responsible for conducting fifty-four projects in six program areas.[8]

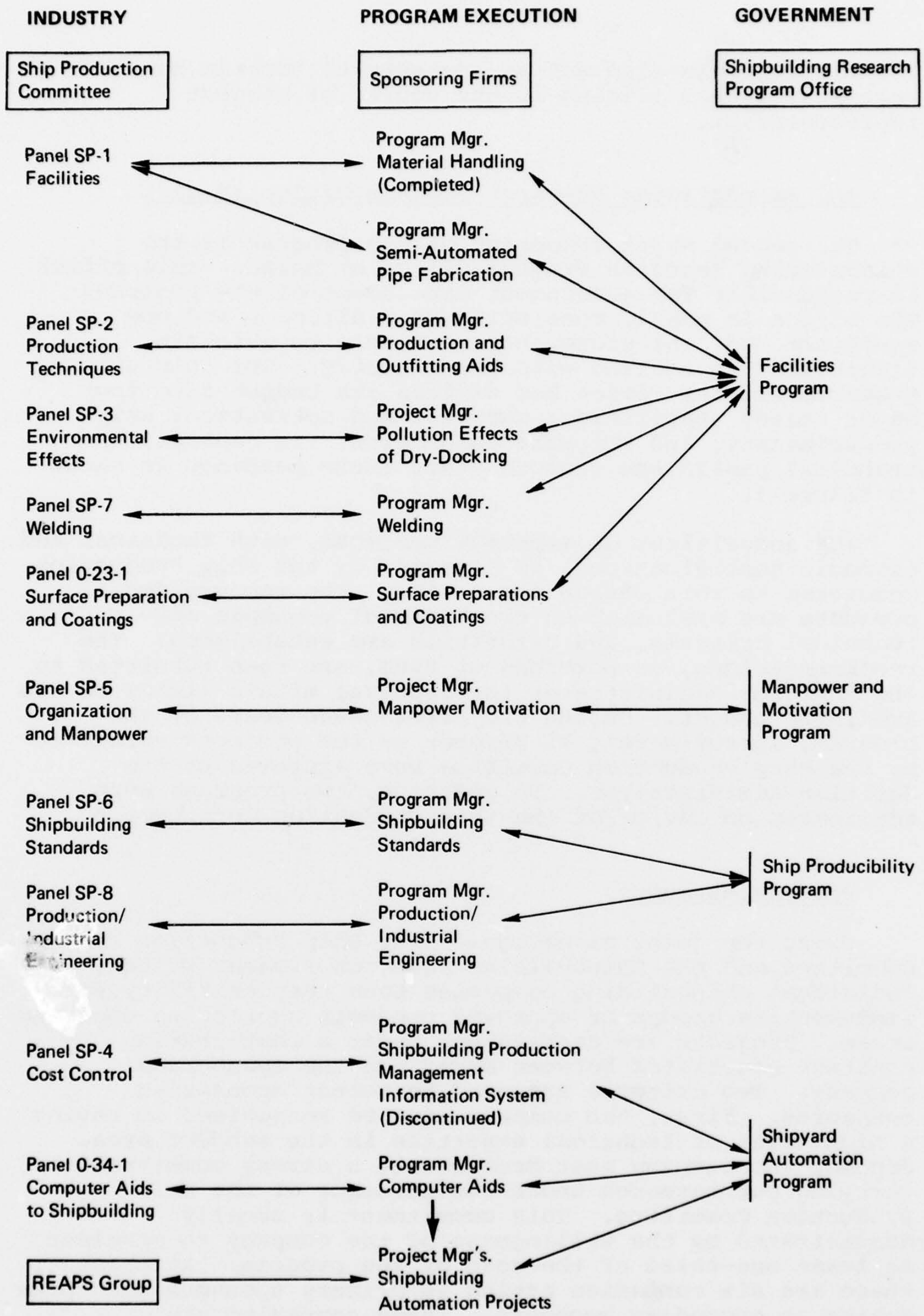

FIGURE 1

NATIONAL SHIPBUILDING RESEARCH PROGRAM

Each of the primary sponsors selects a senior engineer to serve as full-time Program Manager. The Program Manager is responsible to both the Ship Production Committee and the program office of MarAd. The administrative functions of the Program Manager include responsibility for preparing contract specifications, soliciting bids, and monitoring projects and contracts. In addition, Program Managers conduct an ongoing review of the major technical decisions required during the implementation of various projects and provide or secure technical assistance for project staff as needed.

Newly funded projects are assigned to one of the Program Managers. The Shipbuilding Research Program Office confers with the Ship Production Committee in the assignment of specific projects to appropriate sponsoring companies and in the selection of any outside contractors. All projects, including those for which a contract must be let outside of the shipbuilding industry, are placed under the control of a Program Manager employed in one of the sponsoring shipyards.

The cost-sharing formula used by the program is simple. Direct costs, such as the salaries of the Program Manager and his staff and contract expenses, are paid by MarAd. The sponsoring shipyards assume all overhead costs, including office space and materials, and provide plant facilities for any projects conducted in shipyards. MarAd considers this to be an optimal cost-sharing formula since it minimizes paper work and does not require a cash outlay from individual firms.

THE INNOVATIVE PROCESS

The organization of the National Shipbuilding Research Program supports the innovative process in several important ways. First, the established mechanisms for selecting problem areas and defining potential projects ensure that new projects are reality-oriented, meet a problem that has industry-wide ramifications, and are defined after pooling all available technical knowledge. Second, the program structure facilitates the identificaiton of new areas of research. Third, the program design incorporates a means of ensuring that the industry arrives at a consensus on research priorities. Finally, the structure of the program facilitates the rapid dissemination and use of research findings.

The Technical Panels

The activities of the technical panels are crucial to the success of the overall innovative process. Since the

panels are composed of managers and engineers with line-responsibility for ship production, the research projects generated by the panels are usually those that address the most pressing production problems of the industry. This arrangement fosters rapid adoption of research results. Further, since the technical panels concentrate on particular production areas, they tend to generate research projects that are interrelated. One project often complements another or leads to another. Thus, the technical panel structure fosters cumulative technological development.[10]

Greater use of existing information has been an important by-product of the technical panels. Since the process of formulating specifications for individual research projects usually requires pooling technical information, redundant research projects are avoided. As the work of the technical panels has progressed, a number of identified problems have been solved simply by sharing available data. Although the cash savings to both government and industry have not been calculated, a significant number of redundant research projects have been aborted on this basis.

In addition to assuring a reality-oriented approach to research, the technical panel structure has enough flexibility to permit program expansion in promising new areas. For example, by late 1972 the Facilities Panel had developed four successful projects in the area of welding. The Welding Program Manager recommended to the Ship Production Committee that a new panel be formed to focus solely on this area. The Welding Panel was approved by the Ship Production Committee and has proven to be one of the more effective panels in the program. Similarly, the Surface Coating and Preparations Panel emerged from successful projects generated by the Production Techniques Panel.[10]

Conference Strategy

Program expansion may also occur through the identification of new problem areas by the Ship Production Committee or by MarAd. The staff of MarAd's Shipbuilding Research Program Office has developed a problem-oriented conference technique that has proven useful in opening discussions in new areas. The technique reflects the basic philosophy of the program in its simplicity and non-directive approach.

When new problem areas are identified, the Shipbuilding Research Program Office convenes a two- or three-day conference for shipyard representatives and relevant

technical experts. After an initial welcoming meeting, which includes presentations on the nature of the problem or problems to be addressed, control of the meeting is turned over to the participants, who assume responsibility for the remaining conference agenda.[10] Usually, MarAd staff does not participate in working group discussions.

The first conferences of this type were learning experiences for all concerned. Initially, industry representatives were convinced that MarAd officials intended to present the government's solutions to the identified problems at some point during the working sessions. Therefore, the conference participants waited patiently in their working groups, often for as long as a day. When it became clear that MarAd staff did not intend to join the working groups, the industry representatives took command and addressed the issues at hand.

Using the problem-oriented conference technique, new programs have been generated at the request of the Ship Production Committee in the areas of Ship Producibility and Marketing. The recently initiated Research and Engineering for the Automatic Production of Ships (REAPS) program grew out of a conference on the application of computers in ship production, a problem area identified by MarAd staff.

Establishing Priorities

The emphasis on a bottom-up approach to establishing research priorities through the technical panels has not precluded imaginative use of the program's framework to influence research priorities from the top down. Until 1975, the Ship Production Committee approved roughly equal numbers of projects for each technical panel at a total cost that was approximately equal to the projected budget of the Shipbuilding Research Program Office. In an effort to refine the priority-setting system, MarAd and the Ship Production Committee have agreed to a new means of establishing priorities that results in an allocation of resources to those technical panels able to develop the most cost-effective project proposals.

The Ship Production Committee now ranks its final recommendations according to low, medium, and high priority projects. The Shipbuilding Research Program Office requests funds sufficient to support all high-priority and some medium-priority projects and chooses the projects it judges to be of most value. The primary criteria used by MarAd and by the Committee in selecting projects is the potential cost-benefit of the expected project results. An objective formula for calculating estimated cost-benefit has been developed and adopted by both groups. The new system has

tended to reward those panels able to generate projects that are of greatest potential cash value to the industry.

Dissemination and Implementation of Research Results

Finally, the National Shipbuilding Research Program fosters innovation by providing for rapid dissemination of research results and by encouraging rapid implementation. The members of the Ship Production Committee and the technical panels are prime movers in this dissemination and implementation process.

Since both top-level and mid-level shipyard managers and engineers are involved in the conception and management of the projects, they have a vested interest in making use of the results. If the results are ignored, their peers and their management may question why the projects were selected and supported in the first place. Moreover, these people are in key production positions. In short, they have both the motivation and the capacity to speed implementation within their companies. Finally, many of the projects are performed in individual shipyards, and most shipyard opt to continue or expand the projects at the conclusion of the demonstration phase. Therefore, in most cases, demonstration leads smoothly into practice in at least the originating yard.

The principal means of formal dissemination of project results is through demonstrations held in the sponsoring shipyard's facilities. Program Managers are responsible for organizing these demonstrations upon the completion of each project. Representatives from all of the shipyards in the country are invited. Although each shipyard is required to pay all expenses of staff who participate, attendance at demonstrations averages between 100 and 200 industry representatives.[10]

The demonstrations are judged by MarAd to be more effective than written reports in disseminating project results. The impact of seeing a new procedure or process in operation in a familiar setting is significantly stronger than any verbal description. Experience indicates that innovations are most likely to be adopted when they are considered to be of sufficient value by front-line personnel to warrant the risk of persuading top-level management to agree to the change.[10]

Projects that are contracted to current or potential suppliers to the shipbuilding industry have an additional dissemination mechanism. In many instances, the supplier decides to produce and market the equipment developed under federal contract to shipyards and, in some cases, to other

industries. Although marketing by supplier firms is an important diffusion mechanism of the National Shipbuilding Research Program, its effective operation often depends on the supplier's willingness to undertake production and marketing. This decision is based on the supplier's perception of profit potential.

Last, and probably least important as a dissemination mechanism, is the distribution of final project reports. Program Managers are responsible for sending these formal reports to selected production managers in every shipyard. Information about the National Shipbuilding Research Program is also distributed through the MarAd Office of Public Information and through the committee structure of SNAME. The latter method has proven particularly effective. SNAME is enthusiastic about providing this service and underwrites the cost.[10]

PROJECTS AND BARRIERS

The large number of projects carried out under the National Shipbuilding Research Program precludes a complete discussion here. Nevertheless, a brief review of selected projects will help to illustrate the impact of the National Shipbuilding Research Program, as well as to identify some of the major barriers to change it has encountered since 1970. The most successful projects have been those which address improvements in existing operations. Projects attempting to apply technologies from other industries to the problems of shipyards have been less successful. Only recently have projects addressed some of the more entrenched barriers to innovation and technological change, such as standards and regulations. However, these latter projects are of interest as indicators of the success of the overall effort to improve the innovative capacity of the industry.

The Welding Program: A Success Story

One of the biggest success stories in the program has been in welding. This project-group is notable for several reasons. It included one of the first projects that was successful without requiring research funds. It also provides a good example of the development of complementary research efforts. Finally, the welding program has had its share of setbacks, notably in the area of supplier withdrawal from marketing a newly developed product.

When the National Shipbuilding Research Program was started, four independent welding projects were included. One of these, the development of American-made gravity electrodes, was remarkable both for its success and its

brevity. The process of drawing up the specifications for the electrodes relied on pooled technical information and produced a document that articulated the needs of the industry so clearly that an existing vendor agreed to produce and market the product. There was no need to fund a research or demonstration effort. While this is not an isolated example, it provided early and concrete proof to the industry of the value of a cooperative approach to problem solving.

Of the other original welding projects, two are of interest because they illustrate the impact of suppliers on the innovation process. One project was aimed at developing an American capability for one-sided welding of ship hull plates. The second was aimed at developing an improved automatic butt-welder. One-sided welding had a high potential cost savings. Moreover, a suitable machine was available from a foreign supplier, although the price was prohibitive. The automatic butt-welding project was aimed at developing a machine for welding erection master butts in all three positions: the bottom shell, the side shell, and the bilge radius. Vertical welders were available but had proven less than satisfactory in shipyards.[5]

Both projects were sponsored by a major shipyard under the direction of the newly formed Welding Panel. Both were completed successfully and demonstrated. There the similarity ended. The one-sided welding project was terminated after the demonstration. The company responsible for developing the project was a major supplier to the marine market. Yet, despite repeated assurances that the market for the product could be substantial, the company opted not to attempt to produce the product at competitive prices.[5]

The developer of the butt-welder, however, took a leadership role by developing an advanced general-purpose machine from the basic designs used during the project. The new machine was designed and built before all required welding processes for the bottom plate and bilge radius had been developed. Subsequently, another shipyard and a major supplier of products used in the welding process joined in supporting the non-federally funded research efforts needed to enable full use of the new welding machine.[5]

Recent trends in the types of projects undertaken by the Welding Panel illustrate the progressive nature of the innovation process. Innovation, once begun, tends to expand into more difficult and complex problem areas. For example, the problems encountered in the development of the new vertical-butt welding machine suggested the need to re-examine the standards for vertical and horizontal electroslag and electrogas welds. This initial foray into

the area of standards and regulations was suggested by the representative of the industry regulatory body serving on the panel. As a result, other projects aimed at evaluating welding standards which restrict productivity have been formulated, but progress is slow. In general, standards and regulations tend to operate as barriers to innovation.

The Welding Program: Barriers to Practical Change

As mentioned above, the welding program has encountered barriers to change and had its share of setbacks. The different fates of the one-sided welding project and the butt-welding project illustrate some major barriers to innovation in the industry. First, the shipbuilding industry is dependent on and imbedded in a larger framework of American supplier industries, yet the industry has a relatively low purchasing power. For example, shipbuilders spend more for steel than for any other material, yet their purchases total less than 2 percent of the total steel-mill output.[10] Therefore, shipyards lack the necessary economic leverage to induce supplier industries to develop new products.

The National Shipbuilding Research Program has not been able to overcome this supply-inertia entirely. Although the program provides the economic stimulus to develop new products, the decision to mass-produce and market these products is left in the hands of the suppliers. Because of the relatively low purchasing power of the industry, what may appear to be a substantial market from the point of view of the shipyards is, from the point of view of the supplier, not sufficient to warrant the capital investment required to produce and market the desired product. Experience indicates that the larger the supplier company, the less likely it will be to undertake production and marketing.

Government patent regulations also operate as a barrier. Patents on equipment developed under government contract through the program are in the public domain. Therefore, the supplier has no market protection. This barrier tends to discourage the larger companies currently supplying the industry. Few larger companies have been bidding on the available development contracts. Most bids are received from smaller companies that are new to the shipbuilding market. Although public domain ruling on a particular patent may be appealed, the company filing the appeal must prove that it made a substantial capital investment in the development process. Moreover, such appeals are usually time-consuming and costly. The net effect of the government patent regulations is to place a false ceiling on the potential profits to be derived from a new product. If a new product is highly profitable, competing companies may

enter the market immediately and benefit from the labors of the originating company.

Other government standards and regulations also operate as barriers. The government regulatory agencies have traditionally been quite conservative. In response, the industry is reluctant to attempt innovations that might run afoul of the regulatory process and cause expensive production delays.[10] As illustrated by the Welding Panel, the inclusion of representatives from regulatory agencies on the technical panels is helping to reduce this barrier. The regulatory agencies are better informed about the production needs of the industry, and the industry has more opportunities to explore the willingness of the agencies to reevaluate standards and regulations.

In evaluating the overall success of the welding effort, it should be noted that this panel is working to improve existing operations. There is little or no expectation that this aspect of shipbuilding will change substantially in the near future. Other successful panels have also focused on stable and labor-intensive areas of shipbuilding such as fitting, outfitting, painting and surface preparation, and materials handling. Panels that have met with less success are those that address the development of new technologies for the industry or the transfer of technologies from other industries. The history of efforts to incorporate computer technology into the ship production process illustrates some of the barriers to more extensive technological change.

Computer Aids to Manufacturing

There have been three separate attempts to form a technical panel to address the coordinated development and implementation of computer aids to manufacturing in the shipbuilding industry. Originally, this effort was organized under the direction of the Computer Aids to Shipbuilding Panel. This panel proved ineffective because the majority of its members lacked any experience with computer aids to production, and the panel was formed at a time when most technicians in the industry considered computers functional only in the area of ship design. Thus, lack of experience in an essentially new technological field inhibited the development of research projects aimed at transferring the new technology into the shipbuilding milieu.

In a second attempt to incorporate computer technology, a major project was launched to develop a shipbuilding production scheduling and control system. Christened the Shipyard Production Management Information System (SPMIS), the project was started in 1973 and dropped after eighteen

months. Although not completed, MarAd considers the project partially successful since the project was allocated an initial budget of $3.5 million and was terminated after an outlay of only $170 thousand.[8] There is general agreement that this project was begun too quickly. The project specifications were formulated before either MarAd or the technical panel had a clear picture of the needs of the industry. As a result, the project's contractor designed a sophisticated computer system that simply could not be absorbed by the industry. The ongoing feedback mechanisms of the National Shipbuilding Research Program ensured early and cost-saving termination of the project.

The third effort to utilize computer technology to improve ship production has met with greater success. This effort, the Research and Engineering for the Automated Production of Ships (REAPS) project, was conceived concurrently with the SPMIS project and is now in full operation. The REAPS project focuses on the development and implementation of a computer system for controlling numerical steel cutting machines. In 1973, after consultation with the industry, MarAd determined that the best computer-controlled cutting systems available had been developed abroad. The original plan was for MarAd to purchase an exclusive license for the best of these foreign systems and lease rights at a lower cost to any U.S. yards willing to install them. Five yards expressed interest; the Autokon system was leased; and the REAPS project was formally started. After installation of the Autokon system in the five yards, a decision was made to expand the capabilities of Autokon by developing a fully automated system to convert plans for whole sections of ships into cut steel. The project was also to include the development of training programs and user's manuals. These efforts are now under way.[10]

The REAPS project has broken new ground in several ways. For example, it is the first major project to be undertaken that will ultimately require a redistribution of the workload in shipyards. With full computer control, steel can be cut so accurately that there is less need for trimming and fitting in final assembly. However, in order to achieve full computer control, the design department must be more exact in specifying the dimensions of the ship's surfaces. Previous experience has shown that innovations requiring organizational changes, such as redistributing work loads, are less likely to be adopted. However, research suggests that innovations requiring organizational change are more easily adopted when the organization participates in their development.[10] It is hoped that the participatory approach that characterizes all the projects sponsored by the National Shipbuilding Research Program will

facilitate the adoption of far-reaching innovations such as the REAPS system.

The financial arrangements and program management of the REAPS project also represent significant departures from the formula used with other National Shipbuilding Research Program projects. The shipyards participating in the REAPS program contribute 50 percent of the total cost of establishing the system in their yards. A cash outlay is required of the yards rather than the usual commitment to assume overhead expenses. The Ship Production Committee does not exercise direct control over the project. Progress reports are submitted to the Committee to keep them informed, but project control is vested in the Project Manager, the sponsoring firms, and MarAd. The Ship Production Committee is fully in accord with this arrangement since the technology involved in the REAPS system is complex and essentially beyond their field of expertise.

In tracing the history of efforts to incorporate computer technology into the ship production process, two barriers to the innovative process have been illustrated. First, a persistant obstacle to developing projects that focus on the transfer of new technology into the industry is the lack of practical experience with the new technology. Since research priorities and research specifications are formulated by front-line production personnel, it has been difficult to bridge the gap between radically new approaches and the current operating procedures in the yards. Second, the extent of organizational change required to incorporate a new technology tends to operate as a barrier. The history of the REAPS project indicates that this barrier may be more likely to be overcome when the participating yards are in control of the development of the project and when their financial commitment to the project is increased.

Fortunately, the National Shipbuilding Research Program has proven sufficiently flexible to incorporate new approaches to overcoming the barriers to the introduction of major technological changes. Further, as the welding effort illustrates, projects that focus on innovation aimed at improving existing methods have tended to generate successive projects and/or new problems requiring solutions. Moreover, these successive projects tend to become more sophisticated and more innovative. Such efforts tend to expand in the direction of increased supplier participation, increased concern with production methods, and willingness to tackle the more entrenched obstacles to technological change.

EVALUATING THE NATIONAL SHIPBUILDING RESEARCH PROGRAM

The National Shipbuilding Research Program was evaluated in conjunction with an independent study of federally funded industry research and demonstration programs. It has also been formally assessed by an Ad-Hoc Committee of SNAME, and assessed more informally by the staff of the Shipbuilding Research Program Office. The findings of each of these studies will be briefly reviewed.

The Rand Study

In 1976, the Rand Corporation published the results of a detailed study of 24 federally funded research and demonstration programs aimed at stimulating change in non-defense industries. The objectives of the study were to identify major factors associated with successful demonstration projects (as defined by the degree of commercial implementation of the results) and to formulate guidelines for federal agencies to use to improve the results of future projects. For the purposes of the study, projects were selected that involved activities undertaken on a sufficient scale or with sufficient technological grounds to permit rapid translation into commercial use. In other words, demonstration projects were selected that were based on technologies that were well understood but had not been widely adopted.[1]

Three criteria were developed to measure the success of the projects in translating the technology into practice. A project was considered an <u>information</u> success when it was able to reduce uncertainties about the operation of the technology in a real-world setting to the point that potential adopters were able to decide whether or not to adopt, and regulators were able to decide whether or how to regulate. A project was considered an <u>application</u> success to the extent that the local adopters were satisfied with the reliability of the system and the quality of the goods or services. A project was considered a <u>diffusion</u> success to the extent that the technology had passed into use as a result of the activity. Projects were ranked yes or no on the information criterion; high, medium, or low on the application criterion; and little or none, some, and significant on the diffusion criterion.[1]

For the purposes of this study, the National Shipbuilding Research Program was analyzed as a program rather than project by project. The overall program was judged to be an information success. It was noted that the principal area of uncertainty reduced by the program's activities was the relative cost advantages of specific technological innovations. The program was ranked high as

an application success, indicating that the adopters of the technological innovations demonstrated through the program were well satisfied with the quality and reliability of the new methods or machinery. Finally, the program was ranked as a significant diffusion success, indicating that a significant amount of technological change had occurred in the industry as a result of the program. Of the 24 federally funded programs studied, only six, including the National Shipbuilding Research Program, received the highest ratings on all three criteria.[1]

In addition to the report on the findings of the study, a companion volume of in-depth case studies was published by Rand. A number of the conclusions reached in the case study of the National Shipbuilding Research Program are worthy of note. As the first significant research and demonstration program in the area of ship production, the program has been successful in creating a more positive atmosphere for technological change. As the program has evolved, the shipyards have begun to initiate and support their own innovative projects (often based on findings of projects originally supported through the program). Furthermore, equipment suppliers, an important source of technological change in many other industries, have traditionally not generated many innovations for the shipbuilding industry. Because of the program, equipment suppliers are now beginning to respond to the needs of the industry. The program has been particularly successful in increasing communication between shipyard professionals who had previously worked in isolation from their peers in other firms. Some Program Managers have begun to act as information gatekeepers to the industry in their particular fields of expertise. Production specialists and engineers are beginning to rely on these gatekeepers for information on new equipment and techniques. The participation of representatives of regulatory agencies on some technical panels is producing change. Several agencies are beginning to reconsider some of their policies in a more constructive light.[10]

On the negative side, the Rand case study points out that the program will probably have to be funded at a much higher level before fundamental changes in the industry can be realized. It notes that the federal funds provided through the National Shipbuilding Research Program account for only approximately 0.02 percent of the industry's revenues.[10] In discussing this point, however, MarAd officials maintain that the program is funded at a level consistent with its goal of producing innovations that can be realistically absorbed by the industry. Conceding that a 20 percent increase in the funding level might yield a 20 percent increase in absorbable technological changes, MarAd nevertheless believes that any increase over 30 percent

would begin to overload the industry. The returns on research and demonstration investments, in terms of their rate of adoption by the industry, would rapidly diminish.

The Rand case study also notes that the National Shipbuilding Research Program alone cannot stabilize the market for U.S.-built ships nor can it compensate for the lack of incentive for cost-cutting in the shipbuilding industry. This latter factor is seen by Rand as a direct consequence of the protected environment engendered by the federal subsidy program.[10]

In sum, the Rand report rates the National Shipbuilding Research Program as one of the best federally funded research and demonstration efforts aimed at fostering innovation in industry. Although there are, in Rand's view, industry problems that cannot be addressed by the program, a number of substantial positive changes in the shipbuilding industry have resulted from the program's activities.

SNAME's Assessment

In 1975, the Ship Production Committee started its own effort to document the effects of the National Shpbuilding Research Program. An Ad-Hoc Committee composed of three members of SNAME was charged with responsibility for ascertaining the effects that 23 of the program's projects had on each of 6 shipyards. The information for the assessment was to be obtained by personal interviews in the shipyards as well as by observation.[2]

A total of 138 observations of the implementation of sponsored research projects was made possible by interviews at the 6 shipyards. Each observation of the extent of implementation of a particular innovation was assigned a numerical value according to the following scale: 0 = no implementation; 1/2 = qualified implementation; 1 = unqualified application. The 138 observations received a total score of 71.5. Thus, the application rate for the 23 projects was 52 percent.[2]

The Ad-Hoc Committee found that in most cases in which a shipyard reported no application of a project's results, the shipyard personnel were, nevertheless, knowledgeable about the results. The committee therefore concluded that the program had been successful in disseminating research information. The committee also found that the program had been very effective in bringing together professionals to deal with common problems, and that the Ship Production Committee had been successful in preventing inclusion of projects that would benefit only one or a small number of shipyards.[2]

MarAd's Assessment

The staff of the Shipbuilding Research Program Office has not published a formal evaluation of the impact of the program on the industry. It has, however, conducted a continuing assessment of the effectiveness of the program as a part of its general program management function. In April 1976, Jack Garvey summarized his view of the program's impact in a presentation delivered at the SNAME Philadelphia Section meeting. In brief, it was noted that in 1970 the innovative process had been effectively blocked in the shipbuilding industry. By 1976, the program had significantly increased the propensity to innovate within the industry. A new pool of industry innovators had been formed, and the program had over 150 active participants. The technical content of the projects had become more sophisticated, the vendor community more cooperative, and shipyard management more aware that the application of new equipment and methods is beneficial to their organization.[5]

Based on their experiences with the program, the staff of the Shipbuilding Research Program Office had arrived at a number of conclusions about the innovative process in the shipbuilding industry. First, that technological improvements can reduce costs and have the potential to improve the profitability of the industry. Second, small incremental improvements can be more effective than major breakthroughs. Third, in addition to providing resources, management must provide an environment conducive to innovation. Fourth, a cooperative program can be more effective in removing institutional constraints to innovation than programs conducted within individual firms. Finally, that the program appears to have been more effective in creating the necessary information pool and the mechanisms for disseminating this information than in creating the environment necessary for effective innovation.[5]

Two major barriers that have inhibited creation of the maximal environment for innovation had also been identified. The mechanisms controlling government support of projects legislated by the Merchant Marine Act of 1970 are standard federal research and demonstration contracting procedures. Unfortunately, these procedures were designed for the procurement of research services for government use and do not recognize the cooperative nature of the program. Within the industry itself, the instability of the market precludes justification of any long-term investments in research or adoption of new technology. Consequently, investments in new technology that cannot ensure capital recovery during the life of an ongoing contract are avoided.[5]

The three views of the program summarized here are remarkably consistent. The program is judged successful by both the federal and the industry participants. When compared with other federally sponsored commercial research and demonstration projects, the program received the highest possible marks. There is general agreement on the contribution the program has made to strengthening the innovative process in the shipbuilding indsutry. There is also a consensus that some of the major economic barriers to innovation in the industry cannot be significantly altered by the program. Nevertheless, the sense of enthusiasm and vigor that permeates the National Shipbuilding Research Program gives grounds for real optimism about the future. The program has not begun to exhaust its potential sphere of impact. There are new challenges to be met. There is a clear commitment to meet them.

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BARRIERS AND INCENTIVES TO THE ADOPTION OF AN INNOVATION: MARITIME SATELLITE COMMUNICATIONS

William H. Penrose

The world watched and listened when man first set foot on the moon, demonstrating our ability to communicate across as well as travel the awesome reaches of space. That event changed profoundly the everyday life of man on earth. We now watch and listen, in real time, to sports, theatrical, and news events from all parts of the globe. Space-age communications technology routinely extends the power of the computer to help solve problems half a world away. This same technology is now available to improve the operation and financial performance of our ocean transportation system, if only the challenge of change can be met.

SYSTEM CAPABILITIES

Commercial satellite communications service to the marine world started in 1976, with the successful geosynchronous orbiting of three MARISAT satellites over the Atlantic, Pacific, and Indian Oceans. When the third earth station is completed in mid-1978, 24-hour service will be available to all MARISAT-equipped ships operating in the primary maritime areas of the world. The system user can depend on constant, high-quality service, because satellite radio frequencies are not subject to the propagation anomalies so common to marine radio, telegraph, and telex services. Many nations allow use of the system in port, since the narrow, highly directional signals do not interfere with nearby broadcasting stations. The ability to use the system in port and the fact that the shipboard terminal operates automatically means that a ship may be contacted directly at all times. (Even when signal propagation conditions are ideal, the conventional marine telegraph system is available only about 22 percent of the time.) The narrow, directional signal also ensures the privacy of communications via satellite.

Ashore, no special MARISAT terminal is required; any telex, TWX, or telephone set will do. There is no manual message handling at the satellite earth stations; once a circuit has been allocated, message transmission is immediate and direct, allowing discussion and decision by both parties during a single call. Historically, communications by the marine telegraph system have meant message delivery delays of from 8 to 24 hours. In addition, the direct connection makes practical the direct entry of data from the ship into a shore-based computer.

Direct connection extends the power of the computer to those at sea in a practical way. Economically efficient high-data rates may be achieved by coupling a small on-board minicomputer to the shipboard terminal. Drawings, charts, and other graphic material may be transmitted by using an ordinary office telecopier in company with the MARISAT terminal. Finally, the system has a collective-call feature that allows a single telex message to be addressed, simultaneously, to all MARISAT-equipped ships of the same flag or company, or to all such ships in the same geographic area.

INDUSTRY ACCEPTANCE

There seems little question that MARISAT marks the beginning of a new era in ship-to-shore communications. It is, perhaps, the single most significant advancement in marine radio service since Marconi. At this point it is apparent that MARISAT will be able to meet the needs of the maritime community for many years to come. That being the case, one might well ask why so few ships have adopted MARISAT during its first 20 months of commercial availability?

In our rapidly developing technological society, change is almost a way of life. For those accustomed to new ideas, the conservative seaman may seem out of place in the modern world. However, conservatism is a force to be reckoned with. Generally, new ideas are not readily accepted in the marine world. Some reasons for this seemingly contrary attitude are contained in this quotation from "Survival at Sea" by Commander G.W.R. Nicholl, RN:

> "The seaman is traditionally cautious and conservative. These are characteristics born of long contact with an element which permits no liberties; an element quick to anger, a fury

> against whom the finest tempered steel is of no avail; even in its most halcyon mood, the sea's smile is reserved and distant. However solidly strong the ship, it can only be hoped that the sea will tolerate it for a lifetime, for it might well be engulfed on its maiden voyage. Progress in maritime matters is, therefore, generally evolutionary and not revolutionary. It cannot thus be wondered that innovations are accepted with caution."

The transition from sail to steam required more than a century to complete. Fourteen years after patent 7777 was granted to Marconi, it took the sinking of the Titanic to force legislation through the Congress to require fitting of radio transmitters and receivers to all U.S.-flag ships. In more recent times, several U.S. shipping companies sustained severe economic setbacks because they continued to build break-bulk cargo ships long after the container concept had been accepted.

A ship master promoted to fleet manager does not automatically shed his conservatism when he steps ashore. On the contrary, these habits are usually reinforced by the requirements of the new position. Financially successful ship owners have learned the importance of providing a competitive service at least cost. This means that the fleet manager must exert continuous pressure to keep ship operating expenses to a minimum. He is essentially a "conservator" who must make do with the tools at hand. Under the circumstances, it is quite natural to question the need for another, more expensive, radio system--especially since international treaties require retention of the marine telegraph system. Treaty requirements aside, there is no question that the MARISAT system is more expensive than marine telegraph. This will be true as long as MARISAT is viewed as nothing more than a substitute for marine telegraph and as long as fleet managers believe that marine telegraph service is adequate for effective fleet management purposes.

Satellite communication is, of course, much more than just a substitute for the marine telegraph system. In terms of global coverage, signal quality, availability, privacy, services available, and economic efficiency, the system represents a quantum leap forward in service to the maritime community. By the same token, ocean transportation today is not the same as the system that existed just a few years ago. Advances in marine transportation technology,

expansion of intermodal systems, uncertainty in the world at large, and the need for effective communications between merchant ships and U.S. military forces have changed the basic nature of the problem. The sheer size and cost of present-day ships--the high cost of depreciation, insurance, fuel, and other operating costs; the need for increased management attention to the details of operations afloat to reduce voyage delays--all point to the pressing need to improve the effectiveness of merchant ship communications.

INDUSTRY-GOVERNMENT COOPERATION

To demonstrate the benefits of satellite communications to the maritime community, MarAd initiated a jointly funded industry-government project. The program included the installation of satellite communications terminals aboard several U.S.-flag ships, the creation of a computer-based message-handling system to link ships at sea with company offices ashore, and the development of a number of "test plans" to facilitate use of the new system by the participants. The idea was that the companies would become familiar with the system and, once convinced of the potential benefits, would proceed independently to use the system to the best advantage.

Several participants soon realized that to make the best use of the satellite system, it would be necessary to integrate the ship system into the shoreside management information system. Such an integration would necessitate the development of computer software--an investment few were willing to undertake on a one-ship, experimental basis. Faced with this realization, the participants used the system primarily as a substitute for marine telegraph. Although most participants recognized potentially important gains that could be achieved by bringing the computer into the operations department, few could convince top management to make the move. There is some evidence that top management may be reluctant to make such a substantial investment at this time because of uncertain conditions in the industry.

LABOR-MANAGEMENT ACCEPTANCE

The radio-electronics officers' unions have supported the move toward satellite capability. There have been several minor incidents of an apparent lack of cooperation on the part of individual radio officers, but this has been traced to a breakdown in communications between the operator

and management ashore. The American Radio Association-Radio Officers Union (ARA-ROU) group of radio electronics officers asked the Maritime Administration to provide to their union school, on the same basis terminals were installed aboard ship, a satellite terminal that the union could use to train their members in operating the new equipment. This request, unfortunately, has been delayed for a variety of reasons, with the result that the radio-electronics officer groups now feel left out.

Short of outright legislation, there are several steps that the federal government can take to facilitate the use of satellite communications services by the U.S. merchant fleet. A move on the international level to eliminate the treaty requirement for marine telegraph equipment aboard satellite-equipped ships would be a major step. Also, the subsidy act might be revised to provide retrofit construction subsidy for the purchase and installation of satellite equipment aboard existing ships. One important step would be to design, implement, and demonstrate the actual working of an integrated ship-shore management information system, based on the use of satellite communications in conjunction with the corporate computer system. The ready availability of adaptable computer software for such a system will make it much easier for individual companies to commit funds for the installation and operation of shipboard satellite terminals.

THE INNOVATION AND IMPLEMENTATION OF LASH

L. Arthur Renehan

The LASH (Lighter Aboard Ship) ocean transportation system is probably the most dynamic form of new marine technology to be introduced in the last 50 years. Container ships, surface-effect ships, LPGs, and Ro-Pos notwithstanding, it is still the most dynamic; that is, adaptable, motive, and responsive to changing circumstances. The genesis of an idea is rarely easy to trace; the innovator himself is usually uncertain of exactly when his creation took form. Innovation most often results from many original thoughts, several starts, and a variety of problems. In this study, our task is simplified by the fact that the innovator has maintained a close relationship to his creation. Ten years of work preceded the finished product, and today it is still being refined.

We will attempt here to define the instruments that brought the LASH system of ocean transportation to the trade routes of the world. Although economic, political, and social factors bear on every innovation, we will concentrate on the ship itself, the crane, the barges, and the system resulting from their operation. Our interest will be primarily concerned with the technology of the LASH barge-carrying vessel.

THE ENVIRONMENT

In 1964 the world was just awakening to the realities of intermodal transportation on an international scale. The "container revolution" had become an overworked expression for the dramatic change that had taken place in the intercoastal trade of the United States. But most shipowners, true to their conservative natures, considered containerization a special solution to a local problem. Cargo-handling costs and labor problems in U.S. ports,

Puerto Rico, and Hawaii were unique; the rest of the world was not ready for such drastic changes.

As a consequence of this conservative thinking, the plans and specifications for a dramatically different ocean transportation system were lying in the drawer of the desk of a naval architect in New Orleans. Jerome L. Goldman had developed plans for a unique barge-carrying ship some years earlier and had put them aside, convinced shipowners were not yet ready to accept it. Actually, little new construction of general cargo ships was being contemplated at the time. The World War II fleet had been replaced by American owners with similar, but faster, break-bulk vessels, and few were thinking of replacement programs. Most trade routes were overtonnaged; the U.S. export trade had not yet expanded, and the charter market languished.

THE DEVELOPMENT

Despite this state of the industry, a pair of entrepreneurs--Spyros Skouras, father and son--had confidence in the future and had plans to expand their small fleet. A few years earlier they left the motion picture business to purchase Prudential Lines, a small, subsidized, profitable liner company operating from the East Coast of the United States to the Mediterranean. They approached the Maritime Administration with a proposal to build ships and increase the scope of their operation, which would in turn increase the amount of their subsidy.

Nicholas Johnson, a rather unconventional Maritime Administrator who had publicly chastised the industry for its conventionalism, advised the Skourases that it was his intention to reduce subsidy payments. The only way that he would authorize construction subsidies would be for new technology. He wanted innovation, and he wanted the industry to propose it.

The Skourases, with their Hollwood background, were not deterred by this. They turned to Jerome Goldman, who had designed the PRUDENTIAL SEAJET type for them--an innovative and successful break-bulk ship. When asked if he had any new ideas for ships, Goldman told them he had a new intermodal system that he feared the industry was not yet ready to accept. Spyros Skouras and his father urged Goldman to come to New York to present this idea to the Prudential Lines managers. The first reaction of the Prudential staff was lukewarm, and Spyros Skouras suggested that the proposal be studied in-house for a few weeks, and

scheduled a return meeting with Goldman. At the second meeting, management endorsed the concept, and it was decided to apply to the Maritime Administration for construction and operational subsidies.

The idea for a barge-carrying ship had developed gradually in the mind of Jerry Goldman. He knew the fundamental needs of the industry were to solve the problems of high cargo-handling costs and extensive port time for expensive ships. He quite naturally considered barges, as his practice was located in the river port of New Orleans and his firm had designed several barges of various types. The economic transport of barges across oceans was the hurdle. The Navy Landing Ship Dock intrigued him, but a single tier of barges resulted in insufficient cargo and revenue for the cost of the ship, and a double tier of barges would require a depth of more than 70 feet of water--an impractical requirement for world ports. He eventually arrived at the idea of using a gantry crane to lift barges over the stern and stow them in cells.

THE TECHNOLOGY

The technology for the cranes was available. Two manufacturers, Alliance Manufacturing Co. and Morgan Engineering Co., both located in Alliance, Ohio, had the capability of producing cranes with 500 long ton lifting capacity. As these cranes were being used in steel mills, it was necessary to adopt them to shipboard utilization.

Barge size was an intriguing problem, as so many conflicting factors were involved. The standardized final design resulted from years of work and consultations considering the following:

1. Quantity of cargo mix at load port and discharge port.
2. Maximum capacity of crane.
3. Cost per unit vs. capacity.
4. Weight per unit vs. deadweight of vessel.
5. Maximum hatch size for ease of cargo handling.
6. Interior height for cargo accommodation.
7. Maneuverability under tow.

8. Width of locks and waterways.

The LASH barge is the essence of simplicity, a steel box 61 ft, 6 in. (18.75 M) long, 31 ft, 2 in. (9.51 M) wide, with an overall height of 13 ft. (3.96 M). Its hatch opening is 44 ft x 26 ft (13.41 x 7.92 M). It draws 1 ft, 6 in. (0.45 M) when light and 8 ft, 8 in. (2.66 M) when loaded in saltwater. It has a load capacity of 375 long tons and a bale capacity of 19,900 cubic feet.

It is testimony to the designers that the final design of the LASH barge has proven successful to the extent that it is easily integrated into a mixed Mississippi River tow, and, despite strict and complicated rules, is towed in mixed tows regulated by the Rhine River Commission.

THE SEABEE

At this point we should note what must be regarded as one of the strangest coincidences in the history of marine innovation. Simultaneously with Jerome Goldman's development of the LASH vessel, another New Orleansian was at work trying to find an intermodal use for river barges. Frank Nemec, President of Lykes Bros. Steamship Co., working entirely independently of Goldman, developed a barge-carrying ship that eventually become known as the SEABEE. His approach followed similar lines in that he tried the submersion/flotation method of the Landing Ship Dock and rejected it for its draft requirement. The SEABEE uses an elevator system and larger barges than LASH, but its final development proceeded along similar lines and experienced the same delays and frustrations.

PRUDENTIAL/PACIFIC FAR EAST LINES

Prudential Lines now entered a protracted period of development with the Maritime Administration. The agency supported the project, but its mood of subsidy limitation resulted in numerous revisions of financial proposals and consequent delays. Spyros Skouras proposed a 15-ship LASH fleet that would trade worldwide, but MARAD would not agree, insisting that Prudential confine itself to its existing trade route. To gain economies of scale in construction, Mr. Skouras was successful in convincing Pacific Far East Line of the merits of LASH for a ship replacement program. He was thus able to initiate a proposal for eleven ships for the two companies--five for Prudential, six for PFEL.

Invitations for construction bids were extended to all major U.S. shipbuilders, with three responding. The lowest of these was Avondale Shipyards Inc. at New Orleans. In November 1967, more than 5 years after his system had been designed, Jerome Goldman witnessed the contract signing between Avondale Shipyards, Prudential Lines, Pacific Far East Lines (PFEL), and the Maritime Administration for the construction of the first LASH vessels.

Unfortunately, this was not the end of delays. Avondale at this time was experiencing serious production problems in U.S. Navy ships, which prevented the start of work on LASH. It was not until November 1971 that the first ship, LASH ITALIA, was delivered to Prudential.

A comment frequently heard from foreign sources is that LASH is a military-oriented system whose construction was advocated and supported by the Department of Defense. Like all ships built with government construction subsidy, the American LASH vessels are intended to serve as naval auxiliaries in time of war, but LASH is certainly not [illegible] product of military interest--its development was ent[illegible]ly commercial.

INTERNATIONAL PAPER COMPANY

Although general-cargo liner owners may have been showing limited interest in new technology at that time, other owners of special carriers for proprietary cargoes were preparing new ships for service. Lumber shippers in Scandinavia and the Pacific Northwest were trying large engines-aft ships with large, open hatches and fast-acting cranes. Swedish paper manufacturers were working on a system to consolidate terminals, employ unit loads, and use specially designed ships to reduce costs for newsprint, kraft paper, woodpulp, and lumber.

In this country, International Paper Company, the largest paper manufacturer in the world and the largest volume exporter in the United States, was shipping its products in the same manner it had for 40 years. The incentive to change was weakened because in 10 years there had been little increase in ocean freight rates, and hence in costs. Overtonnaging had depressed the general cargo market. Ships were aging, however, stevedoring and cargo-handling costs were going up, and Scandinavian competitors were experimenting with new technology. International Paper felt the problem required attention.

The Problem

The Export Traffic Department of International Paper Company held a position in the structure of the corporation quite common in major manufacturers at that time. It was a "reaction group"--that is, it did little to initiate change or exert an influence on the economics of a sale. Like most major corporations, International Paper had not yet recognized the impact of transportation and distribution costs on sales and profits. Traffic Departments merely processed orders. They purchased the best transportation available at the time the order was to be shipped, without influencing the size or quantity of the order, where it was produced, port of loading, or port of discharge. It would be a monumental task to change the system of international distribution.

To involve all departments with the problem and to find an objective viewpoint, the Export Traffic Department suggested that the company obtain the services of an outside consultant. The firm of Drake, Sheahan, Sweeney and Huff, physical distribution specialists, was engaged to study the problem and to find answers to the following questions:

1. Does International Paper Company ship a sufficient quantity of export tonnage that can be combined to achieve economies of scale?

2. How would a new transportation system influence manufacturing and production?

3. What would be the effect on sales?

4. Could various commodities--linerboard, woodpulp, special papers--be combined and coordinated in production and sales into a single transport system?

5. Would a new system produce savings?

The Drake, Sheahan, Sweeney and Huff study provided positive answers to these questions. There was a need for a system; it would be beneficial, and savings would result. The question remained, what kind of a system?

Swedish papermakers had a lead in new forest products shipping technology at that time. Swenska Cellulosa A.B., with three paper carriers on order, was working on a plan that would change their marketing plan and their entire distribution system in Europe and the United Kingdom. Aware

that a major competitor in the most important overseas market was implementing such changes, International Paper Company accelerated its own study of the problem.

The Analysis

Matson Research Company, a subsidiary of Matson Navigation Company, was selected to perform the advanced study and was asked the following questions:

1. Will economies of ocean transportation offset possible additional costs of production and inland transportation? How much?

2. Will changes in loading ports adversely affect inland distribution costs of products for the domestic market?

3. Are special terminals required at loading and discharge ports? If so, how many? What type? At what cost?

4. What type of ship should be used? Size? Method of cargo handling? Speed? Number?

5. Will the cargo-handling system create labor problems? Damage cargo? Result in savings?

6. What is the itinerary of the ship? Will it satisfy customer requirements? Is it lowest cost?

And last and most important:

7. What about customer acceptance? Will the ship change customer order requirements? Will it require changes in customer inland routing at destination (currently through 29 ports in Europe and the United Kingdom)? To what result?

The galley wireless of the shipping industry is perpetual and pervasive. Conversations with stevedores, terminal operators, and port authorities are bound to lead to inquiries from shipowners. To those inquiries from quality owners from whom a serious, reliable proposal could be expected, International Paper did respond with a request for offers.

While the Matson study proceeded to evaluate the resulting change, three American ship operators and one

Norwegian company submitted proposals for forest-product carriers. Each intended to use large, open-hatch ships, two or three as necessary, equipped with fast gantry or pedestal cranes. The terms of all these offers were attractive. In terms of tons of paper carried over the life of the contract, each proposal represented very large savings in ocean freight.

But to International Paper Company the intended solution was incomplete. In a meeting shortly after the offer was received, the Export Traffic Manager explained to Niels H. Johnsen, President of one of the proposing companies, Central Gulf Lines, that those break-bulk types of forest-product carriers were a shipowner's solution. They solved the carriers' problems of slow cargo loading and vessel turnaround but did not completely solve the problems of the paper company. Rapid cargo handling could be achieved by unitizing woodpulp, using vacuum clamps, large holds, and fast cranes. By limiting the number of loading ports, fast vessel turnaround would result. These are important vessel economies. However, they were large ships, totally dedicated to a single shipper.

Sixteen to twenty thousand tons of paper would have to be accumulated in a special terminal. Sophisticated lift trucks would be needed to move it from place of rest to shipside. At the discharge port the process would be reversed. At the completion of unloading, the vessel would sail after a fast turnaround, and the paper company would be left with 16,000 to 20,000 tons of paper to redeliver to trucks, rail cars, or barges for transporting to the customer or the warehouse.

The Alternatives

At this point Niels Johnsen of Central Gulf said, "Have you ever thought of LASH?" The International Paper Export Traffic Manager replied he was familiar with the system, but it was probably very expensive--such a sophisticated crane and all those barges. ... "Let us put some figures on it", Johnsen replied.

In a few weeks Central Gulf returned with a proposal for a LASH ship and barges with numbers that surprised everyone. Compared to the break-bulk type of forest-product carriers, LASH costs per ton of cargo carried appeared to be competitive. Thus, at about the mid-point of the consultants' study, a new element was considered: How would

a LASH system, as proposed by Central Gulf, work for International Paper?

Matson Research had at this point found there were no insurmountable problems in manufacturing and sales that dollar savings would not solve. They had concluded that a forest-products carrier with fast-acting cranes was the feasible alternative and were analyzing the systems approach to its use. With the LASH proposal as a consideration, the study became an evaluation of three alternatives:

1. Geared forest-products carrier

2. LASH

3. Conventional break-bulk vessels

The Solution

The most important unknown factor in LASH was the feasibility of the barge for forest products. Kraft linerboard and certain types of woodpulp have high stowage factors and are relatively low value. Both are critical points ruling against carriage in a container. In the intended application for International Paper, it was essential that a suitable payload be achieved in a barge. The problem was first attacked with pencil and slide rule. Although the final numbers were encouraging, there remained doubt, due to the roll shape of linerboard and the uneven contours of some woolpulp bales.

Next, a scale model of the barge was built, into which the project manager spent hours fitting scale-sized linerboard rolls made to conform to specific customer order size. Even this was not conclusive, and it remained for the production department of provide an answer, when the manager of the Panama City, Florida, mill offered to build a full-size mockup of a LASH barge. As the Panama City mill produced both linerboard and woodpulp for export and had an ocean terminal, the test situation was ideal. By trial and error it was found that indeed a suitable payload for all commodities of all practical size mixtures could be loaded in a LASH barge.

To take full advantage of a barge system, the shipper quite naturally must make use of all intermodal opportunities. The location of the International Paper Company's mills was most favorable to water transportation. The principal export mills were at Panama City, Florida;

Natchez, Mississippi; Pine Bluff, Arkansas; and Bastrop, Louisiana; all near water-loading points; a new mill to open soon was being built at Vicksburg, Mississippi, close to the river. To further support the concept, many of the export customers were already directing that their orders be transferred to barges at Tilbury for transport to warehouses in the River Thames and into barges in Rotterdam for shipment to Duisburg and Cologne. This advantage in collection and distribution was estimated by Matson to mean an additional saving of $1 million per year at 1967 prices.

The Ports

Curiously enough, although this intermodal feature was important, it was not the most significant factor in the comparison with the geared forest-products carrier. It became evident as the study developed that port authorities were unable to evaluate LASH. As they are primarily in the real estate business, and LASH evidently would not require very much of their kind of real estate, they had trouble developing enthusiasm for the system. Yet it was a major development in shipping; it would provide employment in their ports and bring prestige to their community. It could not be ignored. They decided on a wait-and-see attitude.

However, they did help it. As far as International Paper was concerned, the Port of New Orleans gave LASH substantial support when quoting terms for a terminal for geared forest-products carriers. The Crescent City port offered to provide land for which the paper company would pay rent and on which the paper company could build a terminal at its own expense. The port would then lease the facility to the paper company. Estimated cost of the terminal in 1967 was $4,400,000. The terminal would be used by the forest-products ship three or four days every three weeks, and the rest of the time it would be used for storage and accumulation of a large quantity of paper. By comparison, the LASH barges could be docked and discharged with any amount of cargo at any existing terminal in the port, or at any up-river terminal.

The Decision

In May 1967 Matson Research had completed its work. The evidence showed a LASH system, as proposed by Central Gulf, presented exceptional opportunities for savings, and a geared forest-products carrier would provide good savings at

less risk. It was time to present the findings to the Executive Committee for decision.

The decision would be made by a committee consisting of the President, Executive Vice President-Manufacturing, Executive Vice President-Sales and Marketing, Senior Vice President-Overseas Division, and the Treasurer of the company. The President was new to the job, having been head of the Canadian subsidiary, which depended on exports for the major share of its earnings. He had come up through the "outside" departments--woodlands and manufacturing--and was not a desk-bound type. He was a hands-on manager who wanted prompt decisions. It was obvious a new shipping system stimulated his imagination.

The systems were described, and the advantages and disadvantages explained. Three alternatives were present: a LASH system, a system that employed geared forest-products carriers, or existing tonnage chartered as the opportunity occurred. It was obvious management wanted a system. There were sound savings available, $3,750,000 per year in LASH, $1,680,000 per year in the forest-products carrier. But LASH held the risk factor. The technology was untried and untested; the unknowns were infinite. Would barges work? It all depended on a single unit of mechanism, a solitary crane. Labor's reaction was crucial and unpredictable. In contrast, the forest-products carrier was safe; the technology had been tested, and the savings were assured. The ships could be introduced to service soon and labor problems were very unlikely. Despite this, because the benefits were far greater than those derived from any other means of transport, and the risks were not insurmountable, the Traffic Department and consultants recommended the LASH system.

At the completion of the presentation the committee went into executive session, and 2 hours later the Traffic Department had a decision--negotiate a contract with Central Gulf for a LASH system.

The Agreement

From June through September 1967, International Paper Company and its lawyers negotiated with Niels Johnsen to reach a contract that would be equitable and adequately cover any eventualities in a new and complicated shipping system. The project suffered a setback midway in these negotiations when Central Gulf advised International Paper that the Japanese shipyard from which they had received

prices for the ship had informed them that costs had escalated and a new quotation would be 20 percent higher. This increase would have caused a complete review of the project had not Central Gulf offered a compromise proposal. It was suggested that this increase be paid from their revenues when these revenues surpassed a certain minimum figure. In this manner both parties shared the risk of the cost increase and the benefit of additional revenues. Agreement on this point reflected the spirit of cooperation and the progressive mood of the two companies.

Eventually a contract was agreed on that assigned responsibility for such diverse functions as number and condition of barges, places and times of delivery of barges, interval between deliveries, number and frequency of voyages, insurance, and towage. In general, International Paper Company would pay for barge towage to and from its loading and discharge ports. It would load and discharge the barges and arrange for its own terminal, and Central Gulf would operate the LASH ship, lift barges on and off, and place barges in a fleeting area. In the fall of 1967 the contract was signed and construction began on ACADIA FOREST, the first LASH vessel ever to be built.

The Manager of Information Systems at International Paper expressed the mood of company personnel as the planning began for the introduction of LASH when he said: "This is the first time in my life I have ever experienced an adequate lead time for a program. The ship has to be built, doesn't it?" In spite of this lead time, a great deal of work had to be done. Arrangements for terminals and barge fleeting areas on both ends, towing contracts, and negotiations with government bodies on documentation of cargo and barges required a great deal of time.

Logistics Management

Perhaps the most interesting by-product of the new system was its effect on the company's overseas marketing program. A computer program was designed to provide transportation costs from each production mill where an order could be place to each actual and potential customer in Europe and the United Kingdom for each product in various quantities to be shipped in LASH barges. When completed, this program, reportedly the largest ever prepared for a logistics system, produced information that directed important alterations in the company marketing plan. Meaningful changes in transportation and distribution costs were reflected in net return on certain specific sales and

prompted a redirection of the sales effort. This illustration of logistics management had a broad effect on the structure of International Paper Company and, ultimately, led to the creation of a Distribution and Transportation Department, headed by a Corporate Vice President.

Labor-Management Concerns

Not all the planning was so productive, however. The many hours of meetings and travel devoted to negotiations with the International Longshoremen's Association proved to be mostly fruitless. Erik Johnsen had succeeded his brother as President of Central Gulf when Niels became Chairman, and Erik personally undertook the labor relations assignment for LASH. He initiated conversations with the presidents of the two New Orleans ILA locals. These talks made progress. Eventually, an agreement was reached whereby the barges would be stowed by a gang of the same size as that used on other river barges, and the shipboard gang would be the same size as employed on a containership. The New Orleans presidents, when agreeing to this formula, added it would require approval at the national level by Teddy Gleason in New York.

Erik Johnsen had several meetings with Gleason in an attempt to obtain his approval. But each time, after much talk, Gleason evaded the issue, saying he could not make a decision until he had seen the ship and observed the entire loading operation. The stall is a familiar tactic in collective bargaining, with the advantage always flowing to the negotiator who is not under pressure. Gleason waited until the day ACADIA FOREST was due to arrive in New Orleans for the first time, having rebuffed repeated invitations from Central Gulf and the Shipping Association to negotiate an agreement. He appeared in New Orleans, notified the local presidents that any agreement they may have made with Central Gulf was invalid, and ordered them not to cross any picket lines.

The picket lines appeared in the form of National Maritime Union sailors, who had a contract with Central Gulf for American-flag ships and were picketing the Norwegian-flag ACADIA FOREST as a "runaway flag" vessel. This ruse did serve to delay the vessel and create the under-pressure atmosphere of a labor dispute that serves the union's objectives. The ILA would not work the ship until an agreement was finally reached in which the union was paid a royalty for each ton of cargo loaded in LASH barges. The

royalty was to be paid into a fund to compensate for unemployment due to mechanization.

A sample of positive planning was illustrated by the means used to convince European towboat operators that LASH barges could be towed. In his efforts to negotiate towing contracts with Rotterdam towboat owners, and particularly with Rhine River towboat operators, Erik Johnsen was constantly faced with the question of navigability of the LASH barges. Photographs and models depicted a large steel box, devoid of shear, rake or bow taper--a block that, in the minds of Rhine River men, could not be moved safely in their waters. Convinced that such an unenlightened attitude required basic hands-on experience, Erik Johnson arranged for a group of towboat people from Dutch, German, and French towboat companies and the Rhine River Commission to fly to New Orleans as his guests. They participated in actual trial tows of LASH barges in the Mississippi, and after a day of moving LASH barges along the levee, they returned home, converts to the new system.

THE EXPERIENCES OF LASH OPERATORS

After 9 years of service, it is generally agreed that LASH, as employed by International Paper Company, is an indisputable success. ACADIA FOREST was followed a year later by a sister ATLANTIC FOREST, both vessels becoming the basis for a successful, self-supporting shipping subsidiary of the paper company. Others have had mixed results.

Prudential Lines suffered misfortunes from the outset in its LASH venture. The consequences of the shipbuilding delays were critical. For a time it appeared that the line would pioneer intermodal shipping in the Mediterranean with a revolutionary system, but the delayed delivery of LASH ITALIA coincided with the inauguration of container service by Sea-Land and American Export Lines. From then on it was head-to-head competition between LASH and containers, and in this confrontation LASH was at a disadvantage.

The cargos of the western Mediterranean trade route, from the United States East Coast to southern Spain, France, the West Coast of Italy, and Greece, are mainly finished consumer products, machinery, and foodstuffs in both directions. The American exporter of air conditioners and importer of olives and wine are shipping comparatively small quantities each week. They want frequent, regular service to and from their and their customers' warehouses. In this competition, to provide a liner service between modern ports

in the industrialized world, LASH is at a major disadvantage against containers.

As if the service disadvantage were not enough, LASH began operating on the East Coast under the burden of heavier labor costs than containerships. In one of those paradoxes that the shipping industry provides so well, the LASH system, which is more akin to break-bulk, and therefore more labor-intensive, was penalized more for its "mechanization" than containerships.

It may have been intra-union rivalry or the mood of the bargainers at the time, but when the first Prudential LASH ship entered service, it immediately encountered a labor stoppage, first from the unlikely source of the deck officers' union, which had recently allied itself with the longshoremen, and then from the longshoremen themselves. When these disputes were finally settled, Prudential found itself operating with larger gangs, more restrictive work rules, and the same royalty payments Central Gulf had in U.S. Gulf ports. Without a "base" cargo of bales or rolls of paper, bagged goods or a similar homogenous commodity, productivity gains in barge loading cannot be achieved, and LASH on the East Coast failed to gain economies in cargo handling.

These handicaps notwithstanding, other lines proceeded to order LASH ships. PFEL (Pacific Far East Lines) encountered the same type of competition from containerships as Prudential, with similar results, and it has had to modify its system. Delta Line, Combi Line (the only foreign line to date), Waterman Line, and Central Gulf are all operating LASH ships ordered specifically for their particular services, and all are successful. Of the 21 LASH ships in operation as barge carriers today, 14 are in what could be considered profitable employment. In each of these cases, some or all of the following factors pertain:

1. Inland waterways are utilized on at least one leg of the trade route.

2. Neo-bulk cargoes (bagged goods, bales, rolls or bundles, such as forest products) make up a portion of the carryings.

3. Congested ports or ports of lesser-developed countries are included in the trade route.

There are firm indications of continued expansion of the LASH fleet. Waterman Steamship Company has contracted to

build two additional ships, and the Soviet Union is in the process of building an unknown number.

The Russian government purchased the plans, specifications, and rights from Friede and Goldman, with the blessing of the U.S. government, and is now building LASH ships of 40, 60, and 80-barge capacity. No one in the Western world really knows the intended use of these ships; it is certainly likely they will appear in commercial use in world trade routes.

Jerome Goldman has just completed an evaluation of future employment of LASH and has reached some interesting conclusions. He has found that, of all of the vessels of 15,000 or more tons now being built, or whose keels will be laid in 1978, 80 percent are of the break-bulk type. He further submits that, based on actual costs recently obtained from shipyards, LASH proves to be a less costly investment than break-bulk ships. Goldman explains this surprising premise on the following:

1. He has initiated several economies in the LASH design based on construction and operating experience gained in the last 10 years.

2. Construction cost differences between LASH and break-bulk ships have narrowed.

3. Three LASH ships, each with two sets of barges, can carry the same or greater quantity of cargo in the same period of time as five break-bulk vessels.

4. Three LASH ships, each with two sets of barges, will have the same construction cost as five break-bulk vessels.

Therefore, Goldman advises, a shipowner could build and operate three LASH vessels more profitably than five break-bulk vessels and perform a greater amount of shipping activity. If this argument proves to be convincing, this large break-bulk ship market may turn to LASH.

THE FUTURE

In the search for the perfect world, we must ask what could be done to improve the existing situation. Most operators of LASH vessels are satisfied with the ships and the barge system and believe that if they had to do it over again they would order LASH ships. Pacific Far East Line is

the conspicuous exception to this conclusion. They have converted their remaining four LASH ships to containerships, having previously sold two to Farrell Lines. Prudential Lines, in its long-range plans, intends to operate its three remaining vessels on its subsidized trade route to the Mediterranean, with itineraries tailored to utilize the proven features of LASH. By concentrating on North Africa, Middle East, Turkish, and Black Sea ports, they will market their service toward construction materials and equipment, machinery and oil-well supplies, and cargoes suited to barges and ports where barges are more effective than containers.

The single major misgiving of all LASH operators is the handicap of a labor contract that reduces their advantages in comparison with the container and RO/RO ships they compete with. Although the LASH ship is highly automated, the loading and off-loading of a barge is performed by the giant crane, operated by one man with the guidance of a "talker". The longshoremen's contract requires that the ship hire two gangs, a total of 42 men, for this work. By comparison, a containership loading with one container crane can hire one gang of 21 men. It is ironical that a system featherbedded to the extent of LASH must pay a royalty into a fund intended to compensate for unemployment of longshoremen.

Longshoremen rarely renegotiate a contract to favor management, but this unfortunate agreement is a significant barrier to LASH operators and the one they would most like to change if given the opportunity.

Another change that would have made LASH more versatile would be a container capability. The Prudential container mode was unsuccessful because it served to delay the ship in port and showed that the two systems, barges and boxes, were incompatible in that particular application. There is a need to accommodate containers in every shipping system dealing with general cargo today, and it should be designed into LASH. Either container barges should be developed, or a cellular or on-deck arrangement should be designed that would not totally exclude containers.

Farrell Lines has conducted a careful study of the barge and container mix on its LASH ships in the West Coast-Australia trade. They have concluded it is necessary to accommodate containers and have retained the container crane and container cells in certain holds. The ideal configuration in their trade route lies between 66 barges

and 250 TEUs (twenty-foot equivalent units) and 46 barges and 610 TEUs.

It is a reasonable conclusion that a LASH ship is no different from any other type; its success and profitability depend on the way it is used and where it is used. Efficiently operated on a suitable trade route, it is a profitable shipping system.

PORT OF SEATTLE GROWTH THROUGH MODERN CUSTOMER SERVICES

John Dermody

The concept of the function of a maritime port has changed over the years. The change is best shown by contrasting the following two quotations (emphasis added):

> The basic function of...ports is to provide the facilities and services required to transfer cargo and passengers efficiently <u>between ships and shore</u>.[1]

> The function of a port is to provide for efficient and least cost <u>inter and intramodal transfer</u>, inspection, storage, form change and control of cargo.[2]

If a port is considered only a way point at which cargo is transferred from one mode of transport to another, then the efficiency of the transfer procedure is paramount. The following demonstrates the importance of time in transit and the costs involved at the modal transfer point:

> It is estimated that if the world's ports were to improve their ship, feeder and cargo transfer capacity in line with available ship and feeder technology as much as 60% of port time and related costs could be saved. This would not only reduce port costs by about $15 billion, but also increase shipping capacity by about 20% for a total benefit of about $25 billion which constitutes well over 30% of all expenditures for shipping and port costs in international trade.[2]

> Shipping has been recognized by shipowners and shippers alike as one link in a through-transport system extending from producers to consumers. The total cost concept allows a high degree of

investment to be made at certain sectors of the transport system, and higher charges to be levied there if necessary, if by so doing total costs are reduced.[3]

The old saying "time is money" is especially germane to modern port activity. The greatest saving in total cargo transport time can be made during the port transfer process, not the feeder or shipping transport segments:

On the Australian trade conventional cargo liners spend 50% of their time in port, container ships spend only 12% of their time in port activities. With this increased productivity, nine container vessels are capable of replacing seventy out of the eighty or ninety conventional ships normally employed on the Euro-Australia Service.[3]

But saved ship time is not the only cost saving. Savings are realized by keeping cargoes moving:

The function of a port is not to provide a separate service, but to serve as an integral part of a chain of transport links designed to move cargoes from origin to destination points. Ideally, therefore, the port should provide a capability of continuous flow transfer between land and ocean transport modes. Because of differences in unit vehicle size, of capacity per unit time between ocean and land transport mode, as well as because of problems of effective transport scheduling, direct and continuous inter or intramodal cargo transfer is usually possible only for a fraction of the cargo flow through ports.

Ports serve as multipurpose, special purpose, regional or transshipment ports. The major characteristic of ports today is that they are continually changing and subject to dynamic planning.

Although many ports still largely operate as break-bulk general cargo ports with most of their facilities serving all types of ships, many modern ports today are largely composed of specialized facilities each of which serves one type of ship, cargo form, or both.[2]

The ports of the world had an enormous challenge to meet in the late 1950s: which, if met, would commit them for decades:

> An important consideration is the fact that while the many port users improve their technology continuously and while it takes just a few years to introduce new shipping or feeder transport technology, it takes many more, 5-10 years, to introduce major improvements or changes in ports. Such improvements are as a result of the long development time and large unit cost made only very intermittently and are generally planned for economic lives which greatly exceed those of ocean and land transport users. It is for this reason that cargo transfer and port technology must be planned for a very long future time horizon to assure that technological obsolescence does not occur too early in the economic life of such developments.[2]

This study traces the recent growth of the Port of Seattle (POS), which, by deliberate effort, has become a multi-purpose, multi-terminal port deriving most of its business by providing the services expected of a transshipment point on the great circle route between Pacific Rim ports and central and eastern North America.

The 1911 report by Bogue, "Plan of Seattle," foresaw the essential ingredients.

> The prosperity of a port is not dependent on natural advantages so much as a systematic development of the broadest lines to attract foreign and domestic commerce.... The city offering the most conveniently arranged harbor terminals and furnishing sites for industries and jobbers near well-organized water and rail transportation facilities is the city whose businessmen will be able to underbid their competitors and win prosperity for themselves and their commonwealth.[4]

GROWTH

A few examples of the growth of the Port of Seattle are mentioned to demonstrate the success of the policy of providing good customer services.

Tonnage handled by the Port of Seattle rose 52 percent in the 10 years ending in 1968, but the value of the cargoes handled increased 70 percent in the same period. This was largely because the port was able to capture a greater portion of high-value containerized general cargoes during those years.

The speed with which ships can be turned around at POS today is easily shown by the Port log. A typical example is the log for the vessel "Lion Gates Bridge." She docked at Pier 18 from Tokyo at 0800, 28 January 1978, on voyage No. 47. The day shift started at 0900 with three cranes and handled 783 containers. The night shift, using two cranes, handled 353 containers. The next day shift handled 429 containers, including some repositioning, and was finished by 1500. The ship sailed at 1515, 29 January for a total time in port of 31 hours, 15 minutes.

During this study, numerous examples were discovered demonstrating how the Port reacted to and took advantage of modern needs and equipment. However, as will be shown later, it was not innovations in hardware, or the "tools" of the port business, that led to success; it was the management decisions to acquire the tools and the professional staff to use them that were the important innovations.

Nevertheless, it is useful to report some of the modern techniques now used by the Port before discussing key management innovations. Frankel[2] stressed the new technological developments to which modern ports must respond, which are in the areas of:

1. Increased continuity of cargo flow

2. Better integration of conflicting feeder and ship loading and storage requirements

3. Adaptation of optimum cargo form, containment, and parcel size of ship and feeder requirements (physical form change of cargo in port)

4. Modern magnetic or electronic marking and read-off system

5. Modern (often computerized) cargo inventory, and flow control systems, location control, and warehouse planning

6. Improved cargo transfer and transport devices

7. Controlled and planned cargo inspection (spot test, etc.)

8. Environmental control for cargo quality and port ecological control

9. Improved ship-handling, mooring, and docking methods

10. Facility use and planning such as berth allocation, and equipment and manpower assignment.

Each of these areas of technology as applied to POS is discussed briefly below.

Increased Continuity of Cargo Flow

Modern equipment such as cranes and stackers were installed beginning in the 1960s, and backup space was acquired and converted to van storage. Warehouses left over from break-bulk shipping days were torn down to make yard space. Plans remained flexible during the early days of container technology. New freight terminals have two-thirds less warehouse space than previous ones, to provide yard storage for containers.

Better Integration of Conflicting Feeder, Loading, and Storage

Ideally, it would be most efficient to offload a container directly onto the flatcar or truck that would transport the cargo to its destination. This is seldom possible. The POS, therefore, has provided not only backup space and equipment to store and stack containers in the interim, but also a place where cargoes can be efficiently marshalled, inspected, and cleared through U.S. customs.

Physical Form Change of Cargo in Ports

The Port of Seattle's tariff specialists advise shippers on the advantages, if any, to be gained in changing the form, packaging, and parcel size of goods during their transshipment through Seattle. The Port fosters this activity by coordinating the needs of customers with the capabilities of local freight forwarders.

Magnetic or Electronic Marking and Read-off Systems

A control tower at the largest terminal has proved successful in tracking containers, eliminating the need for marking or read-off systems.

Computerized Inventory and Flow Control, Location, and Warehousing

In the early 1960s the Port of Seattle developed a computer accounting system using punch cards and batch processing. In 1966, a management service firm retained to study the system developed the following recommendations:

1. Create a new organization within POS to handle data processing, as distinct from computerized accounting

2. Purchase hardware and develop programs based on on-line, real-time computing capability

3. Base the program on the bill of lading (not the container) since the BOL is the primary business and legal document of shippers

Such a computing system exceeded the capabilities of the current state of the art, and few vendors could provide it. However, a Burroughs system was purchased in 1968. The system had far greater capacity than was immediately needed.

One problem was to gain acceptance of the new system, both from POS staff as well as customers and freight agents. The software system was built in phases, program module by program module. The first module, on-line by July 1969, handled break-bulk cargo control, which was still 90 percent of the Port's business.

Since the first program module was developed for the more complicated task of handling break-bulk cargoes, it was an easier task to develop programs for mixed-load containers and fully unitized cargoes. During this time, POS was conducting trade negotiations, primarily with Japan. The success of these negotiations depended in part upon a properly working computer program for containerized cargoes. The final stages of this program were developed in less than 5 months, and it was ready by July 1970 when the first Japanese container cargoes began arriving.

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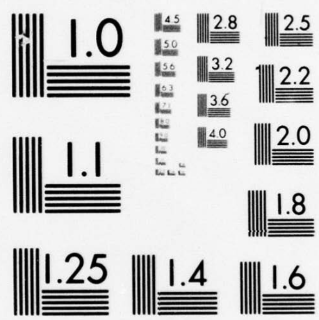

MICROCOPY RESOLUTION TEST CHART
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Since timely service is the most important ingredient the Port can offer to both importers and exporters, real-time, on-line computer control is one of the most important capabilities the Port has developed. The POS keeps control of goods "almost at the retail level," from the time of shipment to ultimate delivery.

When a ship sails for POS, the steamship company sends the entire cargo manifest to the POS Director of Systems and Data Processing via landline, courier, or satellite. The sooner the cargo data are in the computer, the better preplanning the POS can do to expedite the shipments. Steamship companies receive a monthly letter recapitulating their performance as to completeness and timely arrival of cargo manifests.

In response to stated customer needs, POS tailors inventory control for as many as 15,000 importers, 300 of whom actually may have goods in POS warehouses at any one time.

Such a detailed control system provides shippers with many options. For example, an importer can defer decisions about freighting onward from Seattle until the shipment has arrived at POS.

<u>Cargo and Transport Devices</u>

The Port of Seattle's policy since the late 1960s has been to purchase latest model devices to provide for future growth. Three-high stackers were purchased, rather than two-high.

The Port had to keep in mind its chief customer and traditional shipping partner, Alaska. Containerized barge loading facilities were developed simultaneously but separately from terminals designed for trans-ocean vessels. Both roll-on/roll-off and load-on/load-off facilities were built for the Alaska market, as well as loading facilities for railroad barges to Alaska.

The POS has recently retained a consultant to advise and write bid specifications for a maintenance-monitoring system for container cranes. The system is to sense and computer-record key parameters such as motor amperages, pressure differentials, and voltage drops throughout the machinery to assist in diagnosing maintenance needs. The goal is to reduce repair costs and down-time of equipment.

Controlled and Planned Inspections

POS has designed warehouses and the Foreign Trade Zone yards for ease of customs clearance and inspection by shippers.

Environmental Control

The Port of Seattle has become aware (sometimes after the fact) of the need for pollution abatement. Dredge materials are now stockpiled and used by the Port or given away. The airborne dust associated with loading bulk grain is collected by a vacuum system and the material sold to the local animal feed industry. The wash water from the imported vehicle preparation area is recycled to recover and reuse the solvent. The Port provides oily waste pickup service to vessels at the berths.

Ship Handling, Mooring, and Docking

Vessels coming to the Port of Seattle traverse the deep and well-charted waters of the Strait of Juan de Fuca and Puget Sound. The U.S. Coast Guard operates a vessel traffic system with shore-based radar surveillance, and the ships are under the required guidance of a Puget Sound pilot.

The facility used to load railroad barges consists of a two-track ramp delivering cars to multiple track barges. Rather than an elaborate system of switches, the barges are moved laterally to align the ramp and barge tracks.

Use Planning of Berths, Equipment, Manpower

The Port of Seattle uses computer simulation modeling to identify future problems in ship and cargo handling, space, and manpower.

Many shippers solve their own space problem by leasing exclusive berths and space or by obtaining preferential berth assignments. In both cases, the Port retains secondary rights to the berths and spaces.

The Port fosters training of all personnel involved with the Port's longshore activities, whether Port employees or not, by providing classroom space and teaching aids. Stevedoring and longshoring firms and unions utilize these facilities.

MANAGEMENT

As shown above, Frankel's list of areas of new technology is important to the development of modern ports. However, technologies do not, in themselves, explain the growth of the Port of Seattle. Important as the new technologies of the freight business are, they do not, singularly or in concert, necessarily lead to a successful port. Whatever the hardware or technology, a port becomes successful through establishing goals, supporting the good management to achieve those goals, and developing an aggressive marketing effort to attract users.

CHRONOLOGY

A brief chronology of events will serve as an overview to POS development:

1851 First settlers arrived in Seattle (by ship); they came to trade rather than farm.

1893 Culminating many years of organized efforts, railroads came to Seattle, connecting waterfront to Midwest and East Coast.

1895 Virgil Bogue, engineer, issued his first plan for development of Seattle's waterfront.

1898 Alaskan Gold Rush established Seattle as prime supplier and shipper to Alaska, a position POS holds to this day.

1911 Port District Act became law on June 8 after long civic debate. Washington State ports thereby became public and were empowered to plan development of port activity with related transportation systems.

1915 Headquarters building and pier on central waterfront, still used for POS offices today, were dedicated.

1918 Port of Seattle handled 40 percent of all U.S. trade with Japan.

1948 Business and citizen concern regarding post-World War II decline in Port of Seattle activity resulted in formation of Seattle Chamber of Commerce's Port Development and Maritime Committee.

1949 Seattle-Tacoma International Airport dedicated.

1950 Port participated in Trade Mission to Japan (first such U.S. mission to postwar Japan).

1951 Port participated in first postwar Japanese Trade Fair in U.S. held in Seattle.

1956 POS took major step in retaining consulting firm of Booz, Allen & Hamilton to do in-depth study; POS's further major decision was to make report public.

1956 "Ocean-Borne Commerce of the State of Washington," a ports study, was published by Business Executives Research Committee, representing some of the community's most prominent businessmen. It was produced under the direction of Stanley H. Brewer, University of Washington Professor of Transportation, and showed an alarming economic decline in the State's ports.

1957 POS began policy of hiring trained professional staff, one of the first being J. Eldon Opheim as comptroller (later General Manager) with assignment to carry out 60 recommendations of Booz, Allen & Hamilton report. (Note: POS made all recommended changes with one exception; the Foreign Trade Zone was retained.)

1958 Chamber of Commerce sponsored citizens Port Committee, with seven subcommittees to study specific activities of POS, issued memorandum on needs of POS.

1959 KING-TV produced "Lost Cargo," a documentary about the economic problems of the Port of Seattle. All the local media continued demanding POS changes until November 1960 election.

1960 In election, Port changed from three to five commissioners, to serve for $1.00 a year instead of salary, and bond issue was passed.

1960s Ongoing through the 1960s were major capital improvements, purchase of needed backup land, construction of container terminals and berths, expansion of warehousing facilities, buying major equipment such as cranes and straddle carriers, simultaneous strengthening of marketing programs through POS offices in Tokyo, Hong Kong,

Washington, D.C., New York, Chicago, Spokane, and Anchorage.

1962 POS began $30 million terminal building program for Duwamish Waterway.

1964 Sea-Land moved into Terminal 5.

1966 Decision was made to create computer system; management service firm hired to conduct feasibility study; decision made to separate data processing and computer systems separate from accounting department.

1966 Commissioners formally adopted statement of POS "Purposes & Objectives" on March 14, which revised statement adopted November 26, 1964.

1968 Aggressive sales program of POS facilities to overseas customers began, even before facilities were completed.

1970 POS signed agreement with six Japanese containership lines.

1970 New $13 million grain terminal opened at Pier 86 on 40-acre site. Facility can handle largest grain ships in the world.

1972 POS signed agreement with Port of Butte (Montana) for distribution and assembly facility.

1976 Piers 90 and 91, Seattle U.S. Navy Terminal, officially purchased by POS for $15.3 million following lengthy negotiations commencing in 1970. (Piers 90 and 91 had been POS property originally, appropriated by the U.S. Navy for World War II.) The purchase added 198 acres and twin half-mile piers to POS facilities.

POLICY DECISIONS

During the crucial decade beginning in the mid-1950s, the most important policy decision for the development of the Port of Seattle was the emphasis on customer services. Innovative management decisions made in those years are discussed below; they can be categorized as (a) political, (b) financial, and (c) personnel.

Political

Historically, the Port of Seattle has benefited from political involvement:

> The most successful port on the coast will be that port that can impress upon its citizens the financial benefits that a successful port will bring to all residents of its community.[5]

Public ports cannot function without some level of acceptance from the electorate. The people of Seattle and King County became concerned about their declining Port as early as 1948, when the Seattle Chamber of Commerce formed its Port Development and Maritime Committee, and in 1950, when the Seattle Municipal League conducted a study that showed the economic decline in Port activities. This led to the 1956 major study by Booz, Allen & Hamilton for the Port. It is to the credit of the Commissioners that the report, although critical, was made public.

These efforts were useful as thoughtful studies, but were equally useful in arousing public concern. The dailies, Seattle Post Intelligencer and Seattle Times, in both news articles and editorials, brought Port matters to the attention of their readers and called for implementation of the 60 recommendations in the Booz, Allen & Hamilton report. Local trade journals such as the west coast weekly Marine Digest kept Port issues before their readership.

The Chamber of Commerce formed seven subcommittees to look at Port problems. Their efforts were far from cursory, and many of these chamber activities are perpetuated by units of the modern Port organization.

In June 1959, the local broadcast station KING-TV produced the documentary "Lost Cargo," demonstrating the decline of the Port of Seattle.

The media kept the Port and its problems in the attention of the electorate until the November 1960 elections, when the voters changed the Commission from three to five members, serving at $1.00 per year instead of on salary, and provided a $10 million bond issue.

Financial

The concept of unitizing cargoes was not a new idea to Seattle. As early as 1928, Puget Sound Freight Lines (which

serves outlying towns and islands) had used palletized cargo handling. Alaska Steamship Company had experimented with modular cargo boxes for freight containers to Alaska in the post-World War II years.

The Port purchased a few containers in the 1950s to introduce shippers to their use. However, small steps were not sufficient. The ports of the world were faced with many decisions in utilizing modern cargo technology. It was obvious that substantial amounts would have to be spent to modernize.

In the early 1960s, the bonded indebtedness of the Port of Seattle was less than $10 million. (The current issues of bonds amount to approximately $250 million.) The Port entered the era of technological change with large financial reserves. Of all the money spent by POS on facilities since 1911, two-thirds was spent during the decade 1960-1970.

The POS was willing to undertake financial risks. Equipment that was oversized for existing needs was purchased. The Port began demolishing old warehouses and surfacing storage yards at Pier 5 in 1960 before any new construction was designed and before there was any tenant interested in container shipments. In 1964, Pier 5 became the first location for Sea-Land activities in Seattle.

Personnel

The post-World War II studies of POS had included criticisms of the manner of operations, particularly the fact that the commissioners exercised too much responsibility for day-to-day matters.

The Booz, Allen & Hamilton report recommended that the commissioners devote their energies to policy matters and recruit a professional staff to assist the manager in day-to-day operations. Today POS is operated by a staff organized into the following departments:

Executive Director

- Senior Director, Facilities and Operations
- Senior Director, Finance and Administration
- Senior Director, Planning and Port Relations
- Legal Officer

Director, Accounting and Port Auditor
Director, Aviation

Director, Engineering
Director, Marine Terminals
Director, Marketing
Director, Personnel and Industrial Relations
Director, Planning and Research
Director, Public Information
Director, Purchasing and Office Services
Director, Special Services
Director, Systems and Data Processing

To establish and maintain customer relations and to assure that the Port remains attuned to changing customer needs, regional managers operate from marketing offices in New York, Washington, D.C., Chicago, Spokane, Anchorage, Hong Kong, and Tokyo.

RESULTS

The POS has succeeded in becoming, once again, the effective economic force its post-World War II critics wanted. In each of the past 10 years, the POS has set records in operating revenues, cargo tonnage, and container traffic.

The Port has emerged as the container load center of the North Pacific, the number-two container port of the West Coast, and the number-three container port in the nation. In 1976, 16 million short tons moved through POS and 2,470 ship arrivals were recorded. The 1976 direct disbursements to Seattle registered longshoremen amounted to $24,180,378.

The Port now has 52 berths available at 18 terminals. Berth length ranges from 350 to 1000 feet, and depth alongside varies from 18 to 73 feet. Thirteen container cranes, 9 revolving cranes, and 25 three-high stackers are installed at 5 full-container terminals and 7 container freight stations.

Utilizing these facilities are 90 steamship agencies and 14 tug and barge lines. Three railroads, 33 truck lines, and 32 air cargo lines provide feeder service to the Port.

CONCLUSIONS

1. The Port of Seattle recognized its comparatively poor standing among world ports and responded to public pressure for change and improvement.

2. POS recognized that a port, particularly Seattle, is a way point in the total transportation system between supplier and consumer. Port operations are typically more time-consuming and costly than other segments of the total transportation network.

3. POS recognized the need to reduce time spent in port by vessels and their cargoes in order to reduce the customers' total shipping costs.

4. POS purchased and installed facilities, equipment, and control systems necessary to reduce time and costs. POS took financial risks to build for the emerging containerization trend and provide computerized integrated cargo tracking.

5. POS reorganized itself in fundamental ways--changed Commissioners, their number, remuneration and duties, and built a competent professional staff.

ACKNOWLEDGEMENTS

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INNOVATION IN THE MARITIME INDUSTRY: LANDBRIDGE SERVICES

David L. Gorman

Innovation in the maritime industry can take many forms ranging from new equipment to new uses for existing equipment. "Landbridge" services fall in the latter category.

Landbridge services are an innovation in the use of existing technologies. Even the physical form of the concept is as old as recorded history. Landbridges are simply overland links in a marine transportation system that allow the distance traveled to be shorter than it would be in an all-water service.

In the settlement of California the wagon road that crossed the Isthmus of Panama prior to the construction of the canal was a landbridge. It permitted cargoes from the East Coast of the United States to be transshipped at the Isthmus, reloaded on ships on the Pacific Ocean side for final delivery in California. Earlier the same road (or trail) linked the Spanish colonies on the West Coast of South America to the Atlantic. In both cases the long trip around Cape Horn was avoided. An earlier landbridge existed for centuries at Suez, linking Europe with India.

Landbridges as a modern innovation, however, are based on a totally different motivation. Although they take advantage of geography (and are limited by it), the motivation is not simply to save time in transit but rather to permit an operator to extend his range of competition for cargo. By making use of a land link across the United States, a ship operator whose all-water service is limited to the North Atlantic can serve the West Coast of the United States as well as the East Coast--the former by a combination of water and rail service and the latter by all-water service.

In a similar manner, all-water feeder services could extend the same operator's competitive range from the North Atlantic to the Mediterranean, Baltic, or Caribbean Seas. For example, by operating a feeder service from Baltic ports to Rotterdam, a North Atlantic operator could serve those ports in addition to his basic North Atlantic itinerary. Similarly, a Mediterranean feeder service could extend the North Atlantic itinerary to Mediterranean ports. Therefore we have included all-water feeder services as a subset of landbridges.

In both services the innovation consists of using existing transportation systems in ways in which they have been used for centuries to achieve a totally new objective--expansion of the competitive range of the individual ship operator.

It is for the innovator an essentially zero risk, zero investment proposition. It offers an improved product to the consumer with substantial benefit to the innovator. It is a relatively limited innovation in terms of its direct and indirect impacts, which together with its rapid development, permits fairly complete evaluation of its growth and effect on marine transportation.

Bridge traffic has been defined, and perhaps over-defined, in more detail. "Landbridge" is a term sometimes used to describe a bridge service that involves a continental crossing between two water legs. Europe to Japan via the United States or the Soviet Union is an example. "Minibridge" is the most common term (for the most common service) and describes a service involving a water leg and a transcontinental leg. The U.S. East Coast to Japan through West Coast ports is an example. Finally, "microbridge" is occasionally used to define shorter land movements. Since all essentially are the same type of service, it is felt that bridge traffic is an adequate descriptor for all.

THE ENVIRONMENT

Two elements necessary for the development of bridge traffic in its current form developed relatively independently over the past decade. The first of these was containerization. Bridge traffic requires that cargo be handled at least once more than in an all-water service (at the point of transshipment from land to sea or sea to land) and in many cases twice more (when a bridge links two sea passages). While this could certainly be done with break-

bulk cargo, it would be highly uneconomic. With the development of containerization, however, the additional costs associated with transshipments are much smaller relative to the total cost of shipment.

The second element is the unit train, which was originally developed by the railroads to move large quantities of bulk cargos, such as coal, to a single destination. As containerization grew, railroads began quoting rates on container movements that were really extensions of existing rates for carrying trucks. Several plans--trailer on flat-car (TOFC), container on flat-car (COFC), etc.--were developed very early in response to a presumed demand for container and trailer transport by rail. However, such shipments were generally in small numbers of units, from each source to each destination, and were priced accordingly. Bridge service offered the potential of volume movements of containers to the account of a single owner (the ship operator) and a single origin and destination. Given a sufficient volume, the railroads could respond by offering unit train service at greatly reduced rates.

These two elements thus provided a low-cost transshipment procedure and, given sufficient volume, a low-cost land transportation mode. It is doubtful, however, that there would have been any incentive to take advantage of these if the general environment of liner shipping in the past decade had been different. In fact, assuming a reasonable level of prosperity for the liner companies during that period, there would have been a genuine disincentive to offering bridge services. The ship operator who offers such a service does so at the cost of sharing at least some of his revenue with the rail carrier. If he provides an all-water service to the same point as the bridge service (as is the case with operators who serve Japan from both the East and West Coasts of the United States), the bridge option represents a direct loss in revenue, competing with his own all-water service. If he does not provide an all-water service, he must still balance the payments to the rail service against his gains in utilization--not always profitable, as is described in a later section.

In the late 1960s containerization in a very few years was adopted on a massive scale in all major U.S. trades. Container tonnage was added rapidly, and by 1970 a condition of semi-permanent overcapacity was reached. This condition is the result of extensive addition of capacity by independent operators and national flag fleets, made possible by the open conference system that exists in U.S.

trades. In other trades with closed conferences, entry is much more difficult, and as a result, the U.S. trades tend to attract surplus liner tonnage from all the world trades. While trade has grown since then, container capacity continues to be added, and there appears to be no reason to believe that the overcapacity situation will be remedied in the forseeable future.

Container system profits are particularly sensitive to utilization, as the slopes of the lines in Figure 1 indicate. These lines reflect estimated voyage profits on one trade route as a function of utilization of the ship's capacity. "A" is a small foreign-flag break-bulk ship, "B" is a large U.S.-flag break-bulk ship, and "C" is a U.S.-flag containership. Costs and revenues were developed with the assistance of operators in the trade.

It is evident from the slopes of the lines that the containership is much more profitable after it reaches its breakeven utilization than the break-bulk ships. It is equally evident that it loses money faster when utilization is below breakeven. Obviously all three owners have a great incentive to maintain utilization above the breakeven point, but that of the container operator is greater--he has more to gain when he exceeds breakeven utilization and more to lose if he does not. As a result, the impulse toward marginal costing to improve utilization, common to all three, is even stronger for the containership operator.

Given the conditions of overcapacity on many container trades, there is a strong incentive to use whatever means are available to increase utilization. One obvious measure is rate competition, which has been endemic in the container trades in recent years. Ordinarily rate competition is eliminated by the conference system, but with the overcapacity in the container trades the effectiveness of conference control was weakened, and legal and illegal rate cutting became common. Bridge traffic represents a different approach--tapping other trade routes for additional cargo.

In the development of bridge traffic, then, the technological elements were in place and a strong economic incentive existed.

THE GROWTH OF BRIDGE TRAFFIC

Data on the actual tonnage moving in bridge traffic are fragmentary. Census statistics do not identify bridge cargo

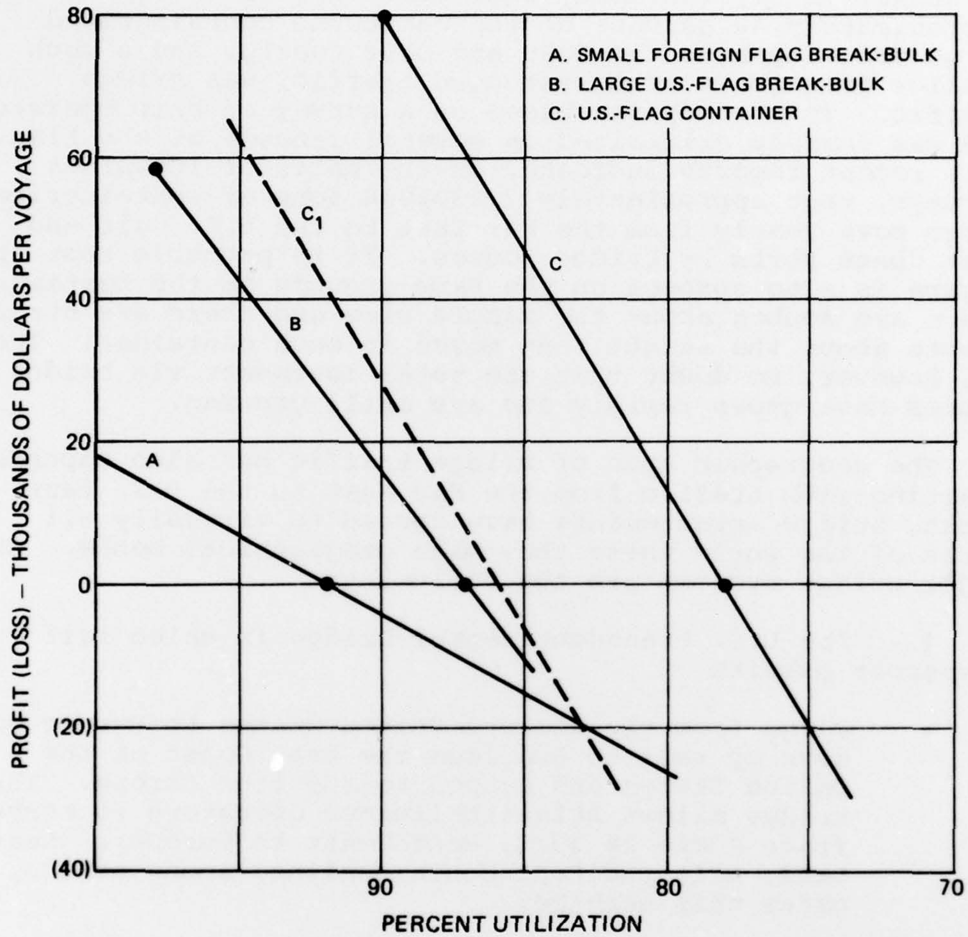

FIGURE 1

VOYAGE PROFITS AS A FUNCTION OF UTILIZATION

as a separate entity. Bridge movements are simply grouped into the customs district where the commodity clears customs. As a result, commodities moving from Japan to the East Coast using the transcontinental bridge are classed as West Coast imports.

In hearings before the Federal Maritime Commission (FMC) in Docket 73-38, testimony indicated that in 1973 approximately 10 percent of the eastbound containerized cargo from Japan to the East and Gulf Coasts, and a much smaller fraction of the westbound traffic, was bridge traffic. This study was based on a survey of ship operators and was sharply criticized on several grounds at the time. More recent reports indicate, on the basis of forwarder surveys, that approximately 2,330,000 tons of containerized cargo move yearly from the Far East to the U.S. Gulf and East Coast ports by bridge routes. It is probable that this figure is also suspect on the same grounds as the testimony. There are doubts about the sample size and there are strong doubts about the weight tons moved in each container. There is, however, no doubt that the total movements via bridge routes have grown rapidly and are still growing.

The geographic span of bridge traffic has also expanded. Starting with traffic from the Far East to the U.S. East Coast, bridge arrangements have spread to virtually all parts of the world where they make geographical sense. Some major bridge systems are the following:

1. The U.S. transcontinental bridge in which rail transport permits

- Cargo from the western United States to Europe to move by rail to and from the East Coast of the United States and by sea to and from Europe. This bridge allows Atlantic-limited operators to serve Trade Route 26 (U.S. West Coast to Europe). Sea-Land, ACL, and Dart Containerline, among others, offer this service.

- Cargo from the East Coast of the United States to and from the Far East to move by rail to and from the West Coast and by sea to and from the Far East. This bridge allows Pacific operators to compete on Trade Route 12 (U.S. East Coast to the Far East). APL, States, Seatrain, the Japanese Consortia, and others are active here.

- Cargo from Europe to the Far East and the Far East to Europe to move by water to the United States and

by rail across the country. This bridge allows lines in the U.S. trades to compete for cargo with the lines on the all-water route from Europe to Japan (via Suez). It also permits competition with the Soviet Trans-Asian bridge.

2. The Gulf bridge in which inland rail connections permit

- Cargo from the Gulf Coast to Europe to move by rail to the southeastern Coast of the United States and by water to Europe. This bridge allows East Coast operators to serve Trade Routes 21 (Gulf to Europe) and 13 (Gulf to Mediterranean).
- Cargo from the Gulf Coast to the Far East to move by rail to the West Coast of the United States and by water to the Far East. This permits West Coast operators to serve Trade Routes 22 (Gulf to the Far East) and 17 (Gulf to Indonesia, Malaysia).

Both of these Gulf bridges are served by the same lines that offer the transcontinental bridge.

3. The European bridge, in which inland European rail or truck connections permit cargo to and from the Mediterranean to move via European Atlantic ports to and from the United States. This allows North Atlantic operators to serve Trade Routes 10 (East Coast to the Mediterranean) and 13 (Gulf Coast to the Mediterranean) as well as, in connection with the U.S. bridge, West Coast to Mediterranean cargo.

4. The Central American bridge service, in which inland truck connections from Panama permit cargo to and from Central America to move on the U.S. intercoastal trade via Panama. This allows intercoastal operators to serve in part on Trade Routes 4 (East Coast to the Caribbean), 23 (West Coast to the Caribbean), and 25 (West Coat to the West Coast of Central America).

The net effect of this spread of bridge traffc is to extend the competitive range of individual operators and conferences to the point where inter-operator competition and inter-conference competition is now almost worldwide. Coupled with all-water feeder services, many major ship operators, formerly constrained to a few routes, can now offer service practically on a worldwide basis.

For example, Seatrain, the originator of bridge traffic in the United States, formerly served only the North Atlantic and North Pacific trade routes. Through bridge traffic it is now essentially serving the entire northern hemisphere.

THE ECONOMICS OF MINIBRIDGE

The economic incentive to the ship operator for the establishment of bridge traffic was discussed briefly in an earlier section. In an effort to further define and set limits on this incentive, costs of operation and freight rates were solicited from several operators. The intent is to show exactly what contribution to the owner's net revenue would be expected from adding or substituting bridge traffic for direct service.

In this analysis the trade route selected is that from Japan to the East Coast of the United States. The bridge operator serves with his own ships the leg from Japan to California, with service to the East Coast provided by transcontinental railroad. The costs are computed from the marine terminal in Japan to the rail terminal on the East Coast. In the case of the all-water competition, costs are from the marine terminal in Japan to the marine terminal in New York. The itineraries are also simplified for easier calculation--direct services in all cases. Costs are <u>representative</u> of U.S.-flag unsubsidized operations.

The results are summarized in Table 1. Voyage costs are for a one-way voyage at 100 percent utilization and do not reflect overall voyage results, since outbound utilization is usually considerably lower than inbound in all three cases. The costs are, therefore, probably low. Voyage costs include wages and fringes, subsistence, insurance, maintenance and repair, fuel, overhead, capital charges, container lease fees, and port costs. Cargo-handling costs include both direct handling charges and an approximation of terminal and equipment costs. In the case of bridge traffic, cargo-handling costs are higher as a result of the additional transfer from marine to rail terminal on the West Coast.

Revenues are based on actual rates for three commodities currently moving in reasonable quantities from the Far East to the United States. Commodity "A" includes electrical and electronic equipment such as medical instrumentation and was selected as a high-rated commodity. Commodity "B", airconditioning equipment and parts, commands an

TABLE 1

RELATIVE COSTS—DIRECT AND BRIDGE SERVICE

21 Knot-1,000 TEU Vessel
20 Revenue Tons/TEU

	Japan-California Direct	Japan-East Coast Direct	Japan-East Coast Bridge Service
Voyage Cost/Unit	$ 194.00	$ 418.00	$ 194.00
Cargo Handling Cost/Unit	285.00	285.00	385.00
Rail Division			
Up to 20 20-Foot Units			588.00
TOTAL COST	$ 479.00	$ 703.00	$1,167.00
Revenue			
Commodity A	$2,020.00	$2,327.00	$2,327.00
Commodity B	1,200.00	1,570,00	1,570.00
Commodity C	1,040.00	1,270.00	1,270.00
Net Revenue			
Commodity A	$1,541.00	$1,624.00	$1,160.00
Commodity B	721.00	867.00	403.00
Commodity C	561.00	567.00	103.00

intermediate rate. Commodity "C", chinaware, was selected as a relatively low-rated commodity. Just as the cost estimates are probably low, the revenue estimates are probably high, since 20 revenue tons for a 20-foot container is a fairly high utilization. The numbers do, however, serve to illustrate the basic economics of bridge service, including some of the incentives and some of the barriers.

Referring back to Figure 1, suppose that the container operator, Line C, is operating close to his breakeven point. This is not a particularly healthy position and there is an obvious incentive to increase utilization. Given the overcapacity that has existed on most container trades since 1970, it is also a not-uncommon position for container operators.

An obvious move for the container operator, if he is to increase his utilization, is to cut rates. The effect of an across-the-board rate cut of 15 percent by the container operator is shown in Figure 1 as curve C_1. He may gain cargo as a result of the rate cut, but his breakeven utilization is also increased substantially. Given a tightly competitive situation, the other lines in the trade can be expected to retaliate (very rapidly if the rate cut is made legally and sooner or later if it is made illegally).

Regardless of the revenue gains from increased utilization, a large portion of those gains must be paid for in reduced revenue for all cargo currently carried by the operator. Selective rate cutting (i.e., rate cuts on selected commodities only) may be more successful, but there is still a price to be paid in decreased revenue on cargo already being carried. Given the inevitable retaliation of the other competitors, rate cutting is not likely to be a profitable exercise, even though it has been the most common approach in the past few years.

Bridge service, however, offers a totally new source of cargo. Even with the additional handling cost and the payment to the railroad, the operator can still make a profit on the bridge containers. The profit is not as great as it would be if he carried the same commodities on his own all-water transpacific trade, but bridge cargoes comprise a very reasonable additional cargo. In effect the highest rated bridge cargoes simply become somewhat more moderately rated cargo for the transpacific operator.

The operator can also be quite flexible in his pricing of bridge cargo. It is not his own rate structure that is

being disturbed. Although bridge rates are usually set for competitive reasons at the same level as the all-water rates, the operator can easily set the rate below the all-water rate to attract more cargo. He can do this without some of the penalties associated with rate cutting in his own all-water trades.

The economic incentive to the operator to offer bridge service is clear--increased utilization of his ships at essentially no cost to himself.

There is also a strong incentive for the shipper to use this service, if offered. The operator is providing the shipper with a potential (and very often, actual) reduction in transit time. From Japan to California, sea time is about 9 days. Transcontinental railroads using unit trains can generally maintain 6-day delivery to the East Coast. Allowing an extra day for transfer from the marine terminal to the rail terminal on the West Coast, total transit time is thus 16 days.

The all-water route takes 21 days from Japan to the East Coast, and therefore a saving of 5 days of transit time can be achieved by using this bridge. To some shippers this is an important incentive--so important that some bridge opponents have insisted that bridge cargoes should carry a premium rate.

Bridge service thus offers a rather rare combination of incentives--a better service to the customer coupled with a positive benefit to the operator. And somebody else pays the bill.

BARRIERS TO BRIDGE TRAFFIC

The barriers to bridge traffic have been essentially legal and raised by those who are actually or can be potentially damaged by its growth. There are four categories of victims, three actual and one potential.

The first, obviously, is the all-water carrier. It is his cargo that makes the bridge service feasible and attractive, and there is very little he can do about it. He really has only two alternatives. The first is to reduce rates to compete with the bridge traffic and hold on to his cargo. In a sense this is like starting a rate war with himself--a war which he cannot win since the bridge operator can simply match his rate cuts and still improve his position, albeit by a lesser amount. Meanwhile the all-

water carrier has reduced his revenue on all his carryings, and most probably has disrupted the conference system on the all-water trade.

The second alternative for the all-water carrier is to offer his own bridge service. Here he moves into competition with himself, and a competition in which the more successful he is the worse off he is. In his high-rated cargo, Table 1, where his all-water service showed a profit of $1624 per container, he is now offering the identical service for a profit of only $1160. The lowest rated commodity, which paid him a respectable $567 on the all-water route, is now almost marginal at $103.

The all-water carrier is indeed hurt by bridge traffic, and hurt badly.

The conference in the all-water trade is also damaged, and in a very fundamental sense. The conference is organized to control rates and competition in the all-water trade, and suddenly it is faced with a competitor who is totally outside its control and, moreover, beyond its reach. The bridge carrier is a member of a totally different conference. The all-water conference, established to control competition, is now in competition with another conference.

A third victim of bridge traffic is the ports serving the all-water trade. Containers that were loaded and discharged in East Coast ports are now loaded and discharged on the West Coast. In principal this loss could be made up by an equivalent bridge movement from the West Coast of the United States to Europe, but this trade is infinitesimal compared to the Far East trade from the East Coast ports. Every bridge container in this trade then represents a loss of work for East Coast longshoremen and a loss of custom for East Coast ports. Conversely, the West Coast ports and labor benefit. Given the complicated container royalty and work preservation provisions, including Guaranteed Annual Income, of the East Coast labor agreements, the Far East bridge has displaced labor and increased costs for <u>all</u> operators using East Coast ports. Eventually these cost increases will be reflected in increased freight rates practically everywhere in the world to and from East Coast ports.

Finally, the greatest potential victims of bridge service may be certain groups of shippers patronizing the all-water route. A glance at Table 1 is sufficient to establish the target of the bridge operator's marketing

effort. The bridge operator will concentrate on the highest rated commodities since, with his higher costs and the railroad division, the lower rated commodities are marginal at best--and most probably would be unprofitable under most conditions.

The all-water rate structure, like all conference rate structures, is based on value of service. It costs the carrier no more to carry a container of commodity "A" than it does of commodity "C". The rates charged are set in such a way that the carrrier profits on the mix of commodities in the trade. He obviously makes a high profit on commodity "A" and very much less on commodity "C".

With the bridge operator making substantial inroads on the higher rated commodities, the all-water operator's revenue structure will be depressed, not only by the loss of cargo but by the skewing of his revenue structure toward a lower average rate. As a result the all-water operator will eventually be forced to raise rates (probably across the board) on a now heavily low-rated cargo mix. These are precisely those commodities and those shippers that can least afford such an increase.

The barriers to bridge traffic therefore have been and are being raised by groups that are genuinely damaged by the new form of competition. Essentially their only recourse is a legal one.

The exact extent of the damage suffered by the injured parties is extremely difficult to determine. This is principally the result of the difficulty in estimating the total number of containers moving on bridges. In the East Coast-Far East trade, for example, many containers listed as bridge containers by the conferences in the Far East to California trade formerly moved on Overland Common Point (OCP)[1] rates to the West Coast and are not a real diversion of cargo. Sharply varying estimates were cited in recent International Longshoremen's Association (ILA) negotiations, but essentially the exact quantities of cargo diverted cannot be estimated.

It is clear that most of the damage to others can be regarded as dislocation rather than injury and need not be permanent. Those injured, however, are difficult to convince.

THE STATUS OF BRIDGE TRAFFIC

The legal reaction to bridge traffic is embodied in FMC Docket 73-38 filed by CONASA (Council of North Atlantic Steamship Associations), the Ports of Boston and Philadelphia, and the ILA in 1973. The respondents were 14 steamship companies that were offering bridge services between the Far East and U.S. East Cost ports. It is known as the Far East Minibridge Case.

The basic charges raised were that bridge rates were "unreasonably low and detrimental to U.S. commerce" and that they were "discriminatory" and resulted in diversion of cargo from the ports' "naturally tributary regions." Following the protracted testimony the FMC Administrative Law Judge made an initial decision in favor of bridge traffic in 1977. The decision essentially rejected the arguments of the complainants.

In the meantime bridge traffic continued to grow and threatened the very existence of some conferences. The whole concept of conference control of rates and competition was called into question by the fact of this inter-conference competition. The response of the conferences has been to propose inter-conference agreements to control bridge rates and practices. In this they have been sharply opposed by the U.S. Department of Justice and by many shippers, who feel that this type of "superconference" will eventually either forbid bridge traffic, force higher rates in bridge traffic, or otherwise reduce its effectiveness as an alternative service. Thus far the opponents have been successful and no such agreements have been approved.

Bridge traffic has become a fixture in many trades and is unlikely, at this point, to disappear, although through conference activity its effectiveness may be constrained in the future. Three other factors may affect the scale of bridge traffic in the future. The first is increased Panama Canal tolls which favor the continued growth of bridge traffic. The second is a demand by the railroads for an increased share of the revenue. This appears to be occurring now and would, of course, adversely affect bridge traffic. Finally, the physical condition of the railroads may also be a limiting factor.

Bridge services are now offered by many carriers, and to a certain extent the same "overcapacity" that exists in the container trades now exists in bridge traffic. Rate competition in bridge traffic has somewhat reduced its appeal to operators, but, in self defense, practically all

operators use it. In the recent ILA strike on the East Coast, bridge traffic to the West Coast was an alternative available for the first time and was used on a vast scale to move cargo to and from the Far East. The effect of the strike on shippers was thus less than in previous strikes.

As an innovation, bridge traffic has been very successful. It usually offers the shipper an improved service and, provided rate levels are not depressed by overcompetition, promotes a new source of remunerative cargo to the operator.

Like most innovations it is also thoroughly disruptive. Its cargo gains come at the expense of the all-water carrier. It shifts the demand for labor and port facilities from one coast to the other, and it has made a strong contribution to the weakening of an already weak conference system in U.S. trades.

NOTE

1 OCP rates have existed for years and were developed to attract cargo from interior points in the United States to the West Coast. They are lower than rates from the West Coast to the Far East and are designed to compete with rates from the East and Gulf Coasts to the Far East.

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This report is a series of seven authored papers that trace the development of seven maritime innovations; LASH (lighter aboard ship), containerization, landbridge, MARISAT, the National Shipbuilding Research Program, NS SAVANNAH, and the marketing techniques of the Port of Seattle. The papers identify barriers and incentives that have affected the development and adoption of each innovation within the maritime industry.

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